Shirpur Education Society's

R. C. Patel Institute of Technology, Shirpur

(An Autonomous Institute)

Course Structure and Syllabus

Final Year B. Tech

Artificial Intelligence and Machine Learning

With effect from Year 2026-27
(RCP23 NEP Scheme)

Shahada Road, Near Nimzari Naka, Shirpur, Maharashtra 425405
Ph: 02563 259 802, Web: www.rcpit.ac.in

Institute Vision

To become a leading Institute in Technical education fostering innovation, research, ethical values, and sustainable development for the betterment of society.

Institute Mission

To impart high quality Technical Education through

1. **Innovative and Interactive learning process and high quality globally recognized instructional programs.**
2. **Fostering a collaborative scientific temper among students with ethical responsibility towards the society.**
3. **Preparing students from diverse backgrounds to have aptitude for employment, entrepreneur ship and research with a spirit of Professionalism.**
4. **To contribute to nation's sustainable development.**

Department Vision

Fostering technical excellence in Artificial Intelligence and Machine Learning through ethics, innovative research, and sustainable education.

Department Mission

1. **Innovative and interactive learning processes with high-quality instructional programs in Artificial Intelligence and Machine Learning.**
2. **Fostering a collaborative scientific temper among students with ethical responsibility towards society in AI and ML applications.**
3. **Preparing students from diverse backgrounds to develop aptitude for employment, entrepreneurship, and research in AI and ML with a spirit of professionalism.**

Programme Educational Objectives (PEOs)

1. **Graduates will have proficiency in Artificial Intelligence and Machine Learning, with lifelong learning skills to advance their careers as professionals, entrepreneurs, and leaders.**
2. **Graduates will possess strong expertise in Artificial Intelligence and Machine Learning, coupled with lifelong learning abilities to excel as professionals, entrepreneurs, and leaders.**
3. **Graduates will apply AI and ML knowledge to solve real-world problems, contributing to sustainable development and societal benefit.**

Program Specific Outcomes (PSOs)

1. **Apply programming, machine learning, statistics, data analysis, and cloud computing skills to develop efficient AI-driven solutions.**
2. **Graduates will excel in Computer Vision, Deep Learning, Natural Language Processing, and Cyber Security while respecting societal values.**

Final Year B. Tech Artificial Intelligence and Machine Learning Semester-VII/VIII (w.e.f. 2026-27)

Sr	Course Category	Course Code	Course Title	Teaching Scheme			Evaluation Scheme					Total	Credit	
							Continuous Assessment (CA)							
							TA	Term Test 1 (TT1)	Term Test 2 (TT2)	Average of (TT1 & TT2)	ESE			
				L	T	P	[A]			[B]	[C]	[A+B+C]		
1	PC	RCP23ACPC701	Reinforcement and Federated Learning	3			25	15	15	15	60	100	3	4
		RCP23ALPC701	Reinforcement and Federated Learning Laboratory			2	25				25	50	1	
2@	PE	RCP23ACPE711	AI in Healthcare	3			25	15	15	15	60	100	3	4
		RCP23ALPE711	AI in Healthcare Laboratory			2	25					25	1	
		RCP23ACPE712	Multimodal Generative AI	3			25	15	15	15	60	100	3	
		RCP23ALPE712	Multimodal Generative AI Laboratory			2	25					25	1	
		RCP23ACPE713	Capital Budgeting and Decision Strategies	3			25	15	15	15	60	100	3	
		RCP23ALPE713	Capital Budgeting and Decision Strategies Laboratory			2	25					25	1	
3#	PE	RCP23ACPE721	AI in Robotics	3			25	15	15	15	60	100	3	4
		RCP23ALPE721	AI in Robotics Laboratory			2	25					25	1	
		RCP23ACPE722	Quantum Computing	3			25	15	15	15	60	100	3	
		RCP23ALPE722	Quantum Computing Laboratory			2	25					25	1	
		RCP23ACPE723	High Performance Computing	3			25	15	15	15	60	100	3	
		RCP23ALPE723	High Performance Computing Laboratory			2	25					25	1	
4	MD	RCP23ACMD701	Cloud Computing	2			25	15	15	15	60	100	2	3
		RCP23ALMD701	Cloud Computing Laboratory			2	50					50	1	
5	EL	RCP23ITELX08	Research Ecosystem		2		50					50	2	2
6	EL	RCP23IPEL701	Project Stage-II			8	50				50	100	4	4
7	HS	RCP23ICHSX09	Disaster Management and Preparedness	2									Audit	
8	SC	RCP23ACSC701	AI for Cybersecurity	1			40					40	1	1
			Total	14	2	16	365			60	315	740	22	

@,# Any one course

Prepared by:
Prof. Dr.N. G. Shinde

Prof. Dr. U. M. Patil
BOS Chairman

Prof. Dr. P. J. Deore
Dean Academics/Dy. Director

Checked by:
Prof. Dr. S.P.Patil

Prof. S. P. Shukla
C.O.E.

Prof. Dr. J. B. Patil
Director

Dept. of AIML R.C.P.I.T. OFFICE SEAL Shirpur

Final Year B. Tech Artificial Intelligence and Machine Learning Semester-VII/VIII (w.e.f. 2026-27)														
Sr	Course Category	Course Code	Course Title	Teaching Scheme			Evaluation Scheme					Total	Credit	
							Continuous Assessment (CA)							
							TA	Term Test 1 (TT1)	Term Test 2 (TT2)	Average of (TT1 & TT2)	ESE			
				L	T	P	[A]			[B]	[C]	[A+B+C]		
1@	PE	RCP23ACPE811	Responsible AI*	3			25	15	15	15	60	100	3	3
		RCP23ACPE812	Social Network Analysis*	3			25	15	15	15	60	100	3	
		RCP23ACPE813	Computational Neuroscience*	3			25	15	15	15	60	100	3	
			NPTEL/Swayam Course#	3			25	15	15	15	60	100	3	
2	EL	RCP23IPELX10	Internship (OJT) cum Project			36	200				200	400	18	
3	SC	RCP23ACSC801	AI in Web3	1			40					40	1	
			Total	4		36	265			15	260	540	22	

@ Any one course

1. *Program Elective Courses offered by institute for the students doing Internship (OJT).
2. #Program Elective Courses offered by NPTEL/SWAYAM for the students doing Internship (OJT).
   These courses are to be studied in self-study mode using NPTEL/SWAYAM platform.

Students doing Internship (OJT) shall submit certificates of NPTEL examination OR they have to appear examinations conducted by institute like TT1, TT2 and ESE.

Students undergoing Internship (OJT) have the option to appear for both the NPTEL examination and End Semester Examination (ESE) conducted by institute for respective course. In such cases, the better of the two scores (NPTEL or ESE) shall be considered for final grading.

List of NPTEL courses will be declared by concerned BOS at the beginning of semester.

Prepared by:
Dr. N. G. Shinde

Prof. Dr. D. R. Patil
BOS Chairman

Prof. Dr. P. J. Deore
Dean Academics/Dy. Director

Checked by:
Dr. S. P. Patil

Prof. S. P. Shukla
C.O.E.

Prof. Dr. J. B. Patil
Director

Dept. of AIML R.C.P.I.T. OFFICE SEAL Shirpur

Artificial Intelligence and Machine Learning
Final Year B. Tech
2026-27
Semester - VII

Program: Artificial Intelligence and Machine Learning	Final Year B. Tech	Semester: VII
Reinforcement and Federated Learning (RCP23ACPC701)		
Reinforcement and Federated Learning Laboratory (RCP23ALPC701)		

Pre-requisite: Machine Learning, Knowledge of Probability, Linear Algebra, and Calculus, Python programming and deep learning frameworks (TensorFlow / PyTorch).

Course Objectives: To provide a comprehensive understanding of Reinforcement Learning (RL) principles, algorithms, and applications, including multi-armed bandits, dynamic programming, temporal difference learning, and deep RL. Students will acquire practical skills in model-free and model-based RL, policy evaluation, and function approximation using neural networks. The course covers real-world applications in robotics, gaming, recommender systems, and industry. It also introduces Federated Learning (FL) fundamentals for privacy-preserving distributed learning. Learners will explore the integration of RL and FL in practical scenarios.

Course Outcomes: On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Explain the fundamental concepts of reinforcement learning, including agents, environments, rewards, policies, and the mathematical foundations such as value functions and Bellman equations.	L2	Understand
CO2	Explain Markov Decision Processes (MDPs) and multi-armed bandit problems using dynamic programming, Monte Carlo methods, and temporal difference learning.	L2	Undesrstand
CO3	Evaluate deep reinforcement learning algorithms, including Deep Q-Networks (DQN) and Policy Gradient methods, for practical problems in games, robotics, and industrial applications.	L4	Evaluate
CO4	Explain the principles of federated learning, including FedAvg, privacy mechanisms, and communication challenges, and analyze potential applications in healthcare, finance, and personalized AI systems.	L2	Understand

Reinforcement and Federated Learning (RCP23ACPC701)
Course Contents

Unit-I 07 Hrs.

Introduction to Reinforcement Learning: Introduction to reinforcement learning. RL Elements: Agent, Environment, Rewards, States, Actions, Policy, History and applications (Games, Robotics, Recommenders, Industry), Mathematical foundations: Rewards, returns, discounting, Value functions (V and Q), Bellman equations, Markov Decision Processes (MDPs): States, actions, transitions, rewards, Episodic vs continuing tasks, Difference between Immediate and Full Reinforcement Learning.

Unit-II 07 Hrs.

Bandit Problems: k-armed bandit, Stochastic rewards, Action-value methods, Exploration vs Exploitation, Bandit Algorithms: ε greedy method, Optimistic initial values, Softmax / Boltzmann exploration, Upper Confidence Bound (UCB),Thompson Sampling Relationship between MAB and RL Non-stationary bandits, Real-world applications: Online advertising: A/B testing, Recommendation systems, Clinical trials.

Unit-III 07 Hrs.

Dynamic Programming & Planning: Model-based RL, Policy evaluation, Policy improvement, Policy iteration, Value iteration, Generalized Policy Iteration (GPI), Convergence issues, Applications: Gridworld, path planning.

Unit-IV 07 Hrs.

Model-Free Prediction & Control: Monte Carlo Methods, Monte Carlo prediction, First-visit vs every-visit MC, Monte Carlo control, Exploring Starts, Off-policy MC & importance sampling, Temporal Difference Methods:TD(0) prediction, SARSA (on-policy control), Q Learning (off-policy control), Expected SARSA, Advanced TD Methods, n-step bootstrapping, Eligibility traces, TD(λ).

Unit-V 07 Hrs.

Deep Reinforcement Learning: Function approximation, Deep neural networks for RL, Deep Q-Network (DQN), Experience replay, Target networks, Variants: Double DQN, Dueling DQN (optional), Policy Gradient Methods: REINFORCE algorithm, Actor-Critic Methods, Case studies: Atari games, CartPole, Robotics control & navigation, Samuel's Checkers Player, Dynamic Channel Allocation, Job-Shop Scheduling.

Unit-VI 07 Hrs.

Federated Learning Fundamentals, Privacy & Applications:

Federated Learning, motivation for decentralized machine learning, centralized learning vs federated

learning, advantages and limitations. Federated Learning architecture: clients, servers, communication cycles, local model training, and global model aggregation. Federated Averaging (FedAvg) algorithm: basic working process and distributed learning workflow. Challenges in Federated Learning: data heterogeneity, communication overhead, device constraints, and scalability issues. Privacy and security in Federated Learning: Differential Privacy, Secure Aggregation, and privacy-preserving AI techniques. Introduction to adversarial attacks and model poisoning attacks, and a basic overview of defense mechanisms.

Reinforcement and Federated Learning Laboratory (RCP23ALPC701)
List of Laboratory Experiments (Any 10)

1. Interacting with an OpenAI Gym Environment (CartPole-v1).
2. Simulate and Model a simple environment (e.g., Gridworld or FrozenLake) as a Markov Decision Process (MDP) by Defining States, Actions, Transitions, and Rewards.
3. Implement a simple MDP and visualize transitions. (Python, Matplotlib)
4. Implement iterative policy evaluation using Bellman expectation equations. (Python, Numpy)
5. Implement Monte Carlo Prediction and Control for a small environment.
6. Implement TD Learning (SARSA and Q-Learning) on a GridWorld environment.
7. Comparison of On-policy and Off-policy learning methods: CliffWalking-v0.
8. Develop a Deep Q-Network (DQN) using PyTorch/TensorFlow CartPole-v1.
9. Implement Policy Gradient and REINFORCE algorithm.
10. Actor–Critic model implementation on a continuous control problem.
11. Introduction to Federated Learning framework (TensorFlow Federated / PySyft).
12. Use federated transfer learning when clients have different feature spaces or label spaces using PyTorch/TensorFlow, heterogeneous datasets (e.g., MNIST & SVHN or image + tabular splits)
13. Implement Federated Averaging (FedAvg) algorithm for MNIST dataset.
14. Evaluate privacy-preserving mechanisms (Differential Privacy in FL).

Oral examination will be based on the entire syllabus including, the practicals performed during laboratory sessions.

Text Books:

1. Soumyadip Sarkar, "An Introduction to Reinforcement Learning", Notion Press, 2025.
2. Saravanan Krishnan, A. Jose Anand, R. Srinivasan, R. Kavitha, S. Suresh, "Handbook on Federated Learning: Advances, Applications and Opportunities", CRC Pr I Llc, 2025.
3. Milad Farsi, Jun Liu, Maria Domenica Di Benedetto, "Model-Based Reinforcement Learning: From Data to Continuous Actions with a Python-based Toolbox (IEEE Press Series on Control Systems Theory and Applications)", Wiley-IEEE Press, 2022.
4. Richard S. Sutton and Andrew G. Barto, "Reinforcement Learning: An Introduction", MIT Press, 2^{nd} Edition, 2020.
5. Laura Graesser Wah Loon Keng, "Foundations of Deep Reinforcement Learning", Pearson Education, 1^{st} Edition, 2020.

Reference Books:

1. Marcus C Lauritsen, "Reinforcement Learning for Beginners: A Step-by-Step Guide to Training Smart AI Agents", Independently Published, 2025.
2. Qiang Yang , Yang Liu, "Federated Learning", Springer / BSP Books, 1^{st} Edition, 2025.
3. George Jeno, "Federated Learning with Python: Design and implement a federated learning system and develop applications using existing frameworks", Packt Publishing, 1^{st} Edition, 2022.
4. Phil Winder, "Reinforcement Learning Industrial Applications of Intelligent Agents", O'Reilly, 1^{st} Edition, 2020.
5. Csaba Szepesvari, "Algorithms for Reinforcement Learning", Morgan & Claypool Publishers, 1^{st} Edition, 2019.
6. Enes Bilgin, "Mastering Reinforcement Learning with Python", Packt publication, 1^{st} Edition, 2020.
7. Brandon Brown, Alexander Zai, "Deep Reinforcement Learning in Action", Manning Publications, 1^{st} Edition, 2020.
8. Micheal Lanham, "Hands-On Reinforcement Learning for Games", Packt Publishing, 1^{st} Edition, 2020.
9. Abhishek Nandy, Manisha Biswas, "Reinforcement Learning: With Open AI, TensorFlow and Keras using Python", Apress, 1^{st} Edition, 2018.

Weblinks:

1. NPTEL Course in Reinforcement Learning:
   https://onlinecourses.nptel.ac.in/noc22_cs75/preview
2. Udemy Course in Reinforcement Learning Top Reinforcement Learning Courses Online - Updated [May 2026]
3. Coursera Course in Reinforcement Learning Reinforcement Learning — Coursera
4. Reinforcement Learning Course (Stanford University):
   https://www.youtube.com/watch?v=FgzM3zpZ55o
5. AI Games with Deep Reinforcement Learning:
   https://towardsdatascience.com/how-to-teach-an-ai- to-play-games-deep-reinforcement learning-28f9b920440a
6. Deep Reinforcement Learning:
   https://www.v7labs.com/blog/deep-reinforcement-learning-guide
7. TensorFlow Federated documentation:
   https://www.tensorflow.org/federated
8. OpenAI Gym documentation:
   https://gym.openai.com
9. Federated Learning What Is Federated Learning? — IBM
10. Federated Learning
    https://blogs.nvidia.com/blog/what-is-federated-learning/
11. Federated Learning 8 Innovative applications of federated learning across the globe - OpenSistemas

Program: Artificial Intelligence and Machine Learning	Final Year B. Tech	Semester: VII
AI in Healthcare (RCP23ACPE711)		
AI in Healthcare Laboratory (RCP23ALPE711)		

Pre-requisite:

- Knowledge of Machine Learning (Supervised/Unsupervised Learning).
- Understanding of Deep Learning and Neural Networks.
- Familiarity with Data Science tools (Python, TensorFlow/PyTorch).

Course Objective(s):

1. To understand the role of AI in transforming healthcare.
2. To learn how to apply AI techniques such as machine learning, deep learning, and natural language processing (NLP) to healthcare data.
3. To gain hands-on experience in working with real healthcare datasets.
4. To discuss ethical, privacy, and regulatory concerns related to AI in healthcare.

Course Outcomes: On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Identify and evaluate various types of healthcare data (e.g., EHR, medical imaging, genomic data) and assess challenges like data privacy, bias, and regulatory constraints.	L5	Evaluate
CO2	Use machine learning algorithms (classification, clustering, time-series analysis) for predictive analytics, diagnostics, and clinical decision support systems using healthcare datasets.	L3	Apply
CO3	Apply deep learning architectures (CNNs, RNNs) for medical image classification, segmentation, and time-series health data analysis, enhancing diagnostic accuracy.	L3	Apply
CO4	Use AI tools to aid in drug discovery and optimize personalized medicine approaches by analyzing genomic data and predicting patient responses to treatments.	L3	Apply
CO5	Discuss and address ethical challenges, privacy issues, and the legal framework surrounding the deployment of AI systems in clinical settings.	L2	Understand

AI in Healthcare (RCP23ACPE711)
Course Contents

Unit-I 06 Hrs.

Introduction to AI in Healthcare:

Overview of AI in Healthcare: Historical perspective, Types of AI systems in healthcare, Role of AI in healthcare transformation.

Key Healthcare Domains for AI Applications: Medical imaging, Diagnostics, Drug discovery, Personalized medicine.

Challenges in Healthcare Data: Data variability, noise, and incompleteness, Data privacy and security concerns, Regulatory constraints.

Unit-II 08 Hrs.

Machine Learning in Healthcare: Introduction to Healthcare Data: Electronic Health Records (EHR), Medical imaging data (X-rays, MRIs, CT scans), Genomics and clinical trial data. Machine Learning Techniques: Classification and regression for disease prediction, Clustering for patient stratification, Time series analysis for health monitoring. **Use cases:** Predictive analytics, clinical decision support systems.

Unit-III 08 Hrs.

Deep Learning in Healthcare: Introduction to Deep Learning Architectures: Convolutional Neural Networks (CNNs) for medical imaging, Recurrent Neural Networks (RNNs) for time-series health data, Auto encoders for anomaly detection.

Applications in Medical Imaging: Image classification, segmentation, and detection in radiology.

Natural Language Processing (NLP) in Healthcare: Information extraction from medical literature and EHRs, NLP applications: Chatbots, virtual assistants, voice recognitions.

Introduction to Federated Learning in Healthcare data

Unit-IV 08 Hrs.

AI in Drug Discovery and Personalized Medicine: AI-Driven Drug Discovery: Introduction to computational drug discovery and AI Case studies: AI in accelerating drug development.

AI for Personalized Medicine: AI-based genomic analysis, Predicting patient responses to therapies, Tailoring treatment plans using AI models.

Unit-V 07 Hrs.

AI Ethics, Privacy, and Regulations in Healthcare: Ethical Considerations in AI for Healthcare: Bias in AI models and its implications, AI decision-making in healthcare. Privacy and Security in Healthcare AI: Handling sensitive healthcare data, Regulations: HIPAA, GDPR, and their impli-

cations for AI. **Regulatory Aspects and AI Approval:** AI in clinical trials and FDA approvals.

Unit-VI 05 Hrs.

Emerging Trends of AI in Healthcare: Wearable AI and Remote Monitoring: AI for patient monitoring using IoT and wearables. AI in Robotics and Surgery: AI-assisted surgeries, robotic platforms, and automation. Telemedicine and AI Integration: AI-driven remote consultations and diagnostics.

AI in Healthcare Laboratory (RCP23ALPE711)
List of Laboratory Experiments (Any 10)

1. Perform data preprocessing (cleaning, normalization) on an EHR dataset
2. Implement classification models (e.g., Decision Trees, Random Forest) to predict disease outcomes using structured healthcare data.
3. Apply clustering techniques (e.g., K-Means, DBSCAN) for patient stratification.
4. Use time-series analysis (e.g., LSTM) for health monitoring, predicting patient vitals over time.
5. Develop a Convolutional Neural Network (CNN) for medical image classification.
6. Implement U-Net or similar architecture for segmentation of medical images (e.g., tumor localization).
7. Use NLP techniques to extract insights from clinical notes or research papers.
8. Perform AI-assisted drug discovery using molecular structure datasets.
9. Use machine learning to analyze genomic data for personalized treatment recommendations.
10. Evaluate bias in AI models trained on healthcare data, and propose solutions to mitigate it.
11. Implement machine learning models to analyze sensor data (e.g., Fitbit) for real- time health monitoring.
12. Use social media, clinical reports, and mobility data to predict disease outbreaks.
13. Review of Research Articles
14. Case Study: Medical Regulations and Compliances

Text Books:

1. Hui Yang and Eva K. Lee, “Healthcare Analytics: From Data to Knowledge to Healthcare Improvement”, Wiley Publication, 2016.

2. Adam Bohr and Kaveh Memarzadeh, "Artificial Intelligence in Healthcare", Science Direct, Academic Press, 2020.
3. Zhou, S. K., Greenspan, H., & Shen, D., "Deep learning for medical image analysis", Academic Press, 2017.

Reference Books:

1. Floridi, L., & Taddeo, M. (Eds.). (2021). Ethics of artificial intelligence in healthcare. Springer / ACM. (Note: The exact editor names may vary slightly depending on the specific volume; Springer publishes multiple editions on AI ethics.)
2. Topol E., "Deep Medicine: How Artificial Intelligence Can Make Healthcare Human Again", New York, NY: Basic Books, 2019.
3. Frangi, A. F., et al., "Medical image analysis", Elsevier, 2023.

Research Paper:

1. Rieke, N., Hancox, J., Li, W., Milletari, F., Roth, H. R., Albarqouni, S., ... & Cardoso, M. J. (2020). The future of digital health with federated learning. npj Digital Medicine, 3(119).
2. Springer. (2020). Internet of Medical Things (IoMT) in healthcare. Springer Publishing.

Online Resources:

1. https://ai.stanford.edu/
2. https://drerictopol.com/tag/medical-ai/
3. https://medicalfuturist.com/
4. https://blogs.nvidia.com/blog/tag/healthcare-life-sciences/
5. https://www.coursera.org/specializations/ai-for-medicine/

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Program: Artificial Intelligence and Machine Learning	Final Year B. Tech	Semester: VII
Multimodal Generative AI (RCP23ACPE712)		
Multimodal Generative AI Laboratory (RCP23ALPE712)		

Pre-requisite: Deep Learning, Large Language Models.

Course Objectives:

1. To provide students with a thorough grasp of image generative AI, including its historical context, key technologies, and applications across various industries.
2. To Equip students with hands-on experience in image generation techniques, manipulation, and evaluation methods.
3. Enable students to explore and analyze the diverse applications of image generative AI in fields such as art, healthcare, and entertainment.
4. Foster an understanding of the ethical considerations and societal impacts of image generation technologies, preparing students to address potential challenges and biases in the field.

Course Outcomes: On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Explain the principles of Image Generation and applications of Image Generation.	L2	Understand
CO2	Compare and contrast various generative models, including GANs and VAEs, and apply their architectures to real-world problems.	L5	Evaluate
CO3	Demonstrate proficiency in using diffusion models and vision transformers in generating images and utilize vision language models.	L3	Apply
CO4	Understand and apply techniques for video generation.	L3	Apply

Multimodal Generative AI(RCP23ACPE712)
Course Contents

Unit-I 07 Hrs.

Introduction and Applications of Image Generation: Overview of Image Generation, Historical Context and Evolution, Challenges, Types of Image Generation Techniques, Applications in Various Industries: Art and Design, Image-to-Image Translation, Super-Resolution, Face Generation, Deepfakes, 3D Image Generation, Overview of Generative Model Families: Likelihoodbased, Implicit, Diffusion, and Energy-based models, Evaluation Metrics for Generated Images : FID, PSNR, SSIM.

Unit-II 07 Hrs.

Generative Adversarial Networks (GANs) and Variants: Architecture of GANs: Generator and Discriminator, Adversarial Training, Variants of GANs (e.g., DCGAN, StyleGAN), BigGAN, Pix2Pix, GauGAN.

Unit-III 07 Hrs.

Generative and Representation Learning Architectures for Images: Introduction to Variational Autoencoders (VAEs), -Variational inference and reparameterization trick. Conditional VAEs (CVAE), Vector Quantized VAE (VQ-VAE, VQ-VAE-2). Representation Learning Architectures :Neural Style Transfer (NST), Siamese Networks and UNET Architecture.

Unit-IV 08 Hrs.

Diffusion Models and Modern Image Generation: Introduction to Diffusion Models, Concepts and architecture overview , De-noising Diffusion Probabilistic Model, Stochastic Differential Equation (SDE), Diffusion Probabilistic Models: Concept & Architecture (DALL-E, Stable Diffusion,Imagen), Comparison: GANs vs VAEs vs Diffusion Models, Hybrid Diffusion Techniques: Latent Diffusion, VQ-Diffusion. Flow based models, ControlNet.

Unit-V 08 Hrs.

Vision Language Models and Image Generation: Introduction to Vision Language Models (VLMs), Transformer-Based Captioning Models :Contrastive Language Image Pairs (CLIP), Vision-and- Language Transformer(ViLT), DeepSeek-VL2, Gemma 3.

Unit-VI 05 Hrs.

Video Generation Models:

Video GAN (VGAN) , MoCoGAN: Decomposing Motion and Content for Video Generation, Video Diffusion Models : TATS (Text-to-Video via Diffusion) model, Video LDM (High-

Resolution Video Synthesis with Latent Diffusion Models).

Multimodal Generative AI Laboratory (RCP23ALPE712)
List of Laboratory Experiments (Any 10)

1. Implement Neural Style Transfer on a set of images and compare results based on different styles.
2. Encode a set of images using autoencoders and visualize the latent space representation.
3. Evaluate the quality of generated images using different metrics (e.g., FID, PSNR).
4. Build and train a basic GAN, observing the training process and quality of generated images.
5. Explore different variants of GANs (e.g., DCGAN, StyleGAN) and report on their performance on a common dataset.
6. Implement and compare a Variational Autoencoder with and without the reparameterization trick.
7. Create and evaluate a hybrid model using VQ-VAE-2 and diffusion techniques.
8. Analyze the architecture of a diffusion model (e.g., DALL-E, stable diffusion) and generate images using available pre-trained models.
9. Explore the application of transformers in image generation and implement a basic transformer model for image tasks.
10. Utilize CLIP to generate text-image pairs and evaluate their relevance and accuracy.
11. Train a U-Net for semantic segmentation on a medical or natural image dataset. Also show how U-Net encoder features can be used for representation learning (e.g., feature extraction for classification).
12. Compare Transformer captioners (ViLT) vs. CLIP-guided prefix tuning vs. Gemmastyle multimodal decoder. Evaluate how (a) direct vision-language transformers(ViLT), (b) contrastive CLIP features + small prefix-tuned decoder, and (c) a modern multimodal decoder (Gemma-style) perform on image captioning.
13. Classic Video GANs: Compare VGAN vs MoCoGAN for short action clips (decomposing motion & content) Implement and compare VideoGAN (VGAN) and MoCoGAN on generating short (1–3s) synthetic videos conditioned on action labels; emphasize decomposition into content and motion latent factors.
14. Create a project that showcases the interaction between text and images, evaluating the generated outcomes.

Text Books:

1. Denis Rothman," Transformers for Natural Language Processing- Build innovative deep neural network architectures for NLP with Python, PyTorch, TensorFlow, BERT, RoBERTa, and more" , Second Edition, Packt Publishing, 2023.
2. Zonunfeli Ralte, Indrajit Kar, "Learn Python Generative AI: Journey from autoencoders to transformers to large language models", First Edition 2024, ISBN: 978-93-55518-972.
3. Soon Yau Cheong, "Hands-On Image Generation with TensorFlow: A practical guide to generating images and videos using deep learning", Packt Publishing, 2020.
4. David Foster, "Generative Deep Learning: Teaching Machines to Paint, Write, Compose, and Play", O'Reilly Media, Inc. June 2019, ISBN: 9781492041948.

Reference Books:

1. Martin Yanev, "Building AI Applications with OpenAI APIs: Leverage ChatGPT, Whisper, and DALL-E APIs to build 10 innovative AI projects, Second Edition" Packt Publishing, 2024.
2. Amita Kapoor, Antonio Gulli, Sujit Pal, "Deep Learning with TensorFlow and Keras – 3rd edition: Build and deploy supervised, unsupervised, deep, and reinforcement learning models" , Third Edition, Packt Publishing, 2022.
3. V Kishore Ayyadevara, Yeshwanth Reddy, "Modern Computer Vision with PyTorch: Explore deep learning concepts and implement over 50 real-world image applications" Packt Publishing, 2020.
4. Martinez, "TensorFlow 2.0 Computer Vision Cookbook: Implement machine learning solutions to overcome various computer vision challenges", 1st Edition, " Packt Publishing, 2021.

Weblinks:

1. https://www.tensorflow.org/tutorials/generative/style_transferhttps://openai.com/index/clip/
2. https://www.coursera.org/specializations/deep-learning
3. https://medium.com/@zhonghong9998/neural-style-transfer-creating-artistic-images-withdeep-learning-803409fc64c0
4. https://medium.com/@outerrencedl/a-simple-autoencoder-and-latent-space-visualizationwith-pytorch-568e4cd2112a
5. https://pyimagesearch.com/2020/03/30/autoencoders-for-content-based-image-retrievalwith-keras-and-tensorflow/
6. https://realpython.com/generative-adversarial-networks/
7. https://towardsdatascience.com/reparameterization-trick-126062cfd3c3
8. https://shashank7-iitd.medium.com/understanding-vector-quantized-variationalautoencoders-vq-vae-323d710a888a

Program: Artificial Intelligence and Machine Learning	Final Year B.Tech.	Semester: VII
Capital Budgeting and Decision Strategies (RCP23ACPE713)		
Capital Budgeting and Decision Strategies Laboratory (RCP23ALPE713)		

Pre-requisite: Foundation of Finance, Quantitative Finance, Financial Market and Risk Analysis, Pricing Models.

Course Objectives:

To develop advance statistics skills for financial data analysis.

Course Outcomes: On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Apply simple and multiple regression models for data analysis, while addressing violations of classical regression assumptions.	L3	Apply
CO2	Analyse advanced econometric techniques for time series analysis to extract insights from economic data.	L4	Analyze
CO3	Evaluate practical econometric skills to solve real-world economic problems and apply theoretical knowledge to data analysis. Analyse risk and return metrics, and evaluate asset pricing using CAPM, APT, and multi-factor models.	L5	Evaluate

Capital Budgeting and Decision Strategies (RCP23ACPE713)
Course Contents

Unit-I 07 Hrs.

Foundations of Financial and Insurance Decision Frameworks: Overview of financial decision-making in data-driven contexts; Role of insurance as a risk transfer mechanism; Expected utility theory, risk aversion; Financial statements (Balance Sheet, Income statements, Cash flow) and key ratios including profitability, liquidity, and solvency ratios; Introduction to forecasting and handling uncertainty in financial planning.

Unit-II 08 Hrs.

Investment Decisions and Capital Budgeting under Risk: Concept of time value of money; Techniques for investment evaluation including Net Present Value (NPV), Annual Rate of Return (ARR), Internal Rate of Return (IRR), Profitability Index (PI), and Payback Period; Risk-adjusted discount rate; Sensitivity analysis and scenario analysis for risk evaluation; Integration of insurance-based risk mitigation.

Unit-III 08 Hrs.

Financing and Capital Structure Decisions: Sources of finance including equity, debt, and hybrid instruments; Estimation of cost of capital—Cost of Equity (Ke), Cost of Debt (Kd), and Weighted Average Cost of Capital (WACC); Theories of capital structure including Net Income (NI) approach, Net Operating Income (NOI) approach, Modigliani–Miller (MM) proposition, and Traditional theory; Leverage impact and determination of optimal capital structure considering risk and return.

Unit-IV 07 Hrs.

Dividend, Payout and Working Capital Management: Theories of dividend policy including Walter, Gordon models; Dividend policy models such as stable dividend, residual dividend, and constant payout ratio models; Share buyback and payout optimization strategies; Overview of working capital management including management of cash, receivables, inventory, and payables; Concepts of liquidity risk and short-term financing options.

Unit-V 06 Hrs.

Financial and Insurance Risk Analytics: Types of financial and insurable risks; Risk–return trade-offs and portfolio diversification principles; Basics of Value at Risk (VaR); Use of predictive analytics and data-driven forecasting techniques for financial and insurance risk assessment.

Unit-VI 06 Hrs.

Simulation-Based Decision Modeling:

Monte Carlo simulation for investment and portfolio decision-making; Scenario-based decision analysis for uncertainty modeling; Conceptual introduction to Markov Chain Monte Carlo (MCMC) methods; Integrative case on combined financial and insurance risk simulation for portfolio or project decisions.

Capital Budgeting and Decision Strategies Laboratory (RCP23ALPE713)
List of Laboratory Experiments (Any 10)

1. To analyze Balance Sheet, Income Statement, and Cash Flow Statement of a company and interpret financial performance. To calculate profitability, liquidity, and solvency ratios and evaluate financial health.
2. To estimate future cash flows using basic forecasting techniques under uncertain conditions.
3. To study investment choices under risk using expected utility theory and risk aversion concepts.
4. To compute present value, future value, and annuities for investment decisions. To evaluate investment projects using Net Present Value technique.
5. To determine project viability using Internal Rate of Return.
6. To assess projects using payback period and profitability index methods.
7. To evaluate best-case, worst-case, and expected-case investment scenarios.
8. To analyze the impact of changes in project variables on investment decisions.
9. To calculate cost of capital components for financing decisions. To determine WACC and analyze its role in capital budgeting.
10. To compare capital structure theories and identify optimal financing mix. To study operating and financial leverage and their effect on returns.
11. To evaluate dividend decisions using classical dividend valuation models.
12. To analyze cash, receivables, inventory, and payables for liquidity management.
13. To estimate financial risk exposure using Value at Risk.
14. To simulate uncertain investment outcomes using Monte Carlo methods.
15. To evaluate combined financial and insurance risks in a project or portfolio using simulation-based decision modeling.

Text Books:

1. Brigham, E. F., & Houston, J. F. (2022). Fundamentals of Financial Management (13^{th} Edition). Cengage Learning.
2. Benninga, S., & Mofkadi, T. (2022). Financial Modeling (5^{th} Edition). MIT Press, Cambridge, MA.
3. Brealey, R. A., Myers, S. C., Allen, F., & Edmans, A. (2022). Principles of Corporate Finance (14^{th} Edition). McGraw-Hill Education.

Reference Books:

1. Bodie, Z., Merton, R. C., & Cleeton, D. L. (2025). Principles of Finance. Cambridge University Press
2. Ross, S. A., Westerfield, R. W., & Jaffe, J. (2024). Corporate Finance (13^{th} Edition). McGrawHill Education.

3. Bigel, K. S. (2023). Corporate Finance. Open Touro University Press (Open Access).

Weblinks:

1. Aswath Damodaran – Applied Corporate Finance: A User's Manual (4th Edition, NYU Stern) https://pages.stern.nyu.edu/ adamodar/pdfiles/acf4E/acf4Ebook.pdf
2. Aswath Damodaran – Chapter 10: Investment Return Models (Applied Corporate Finance, 3rd Edition) https://pages.stern.nyu.edu/ adamodar/pdfiles/acf3E/ch10.pdf
3. Quoc Trung Tran – Dividend Policy: A Business Perspective (Emerald Publishing, 2023) https://bookstore.emerald.com/media/preview/9781837979882-23-2.pdf
4. Quantitative Financial Analytics and Risk Modelling (Routledge, 2021) https://api.pageplace.de/preview/DT0400.9781000320497_A40695981/preview9781000320497_A40695981.pdf

Program: Artificial Intelligence and Machine Learning	Final Year B. Tech	Semester: VII
AI in Robotics (RCP23ACPE721)		
AI in Robotics Laboratory (RCP23ALPE721)		

Pre-requisite:

1. Python programming and familiarity with scientific libraries (NumPy, Matplotlib, OpenCV, PyTorch/TensorFlow).
2. Understanding of Machine Learning and Deep Learning fundamentals: model training, CNNs, backpropagation, and evaluation metrics.
3. Basic knowledge of linear algebra, calculus, and probability as applied in AI and engineering systems.
4. Familiarity with Linux/Ubuntu environment, terminal usage, and package management (apt, pip, conda) is recommended.

Course Objective(s):

1. Introduce the integration of AI techniques with robotic systems covering perception, planning, control, and learning.
2. Explore classical and learning-based methods for robot motion planning, navigation, manipulation, and autonomous decision-making.
3. Provide hands-on experience with ROS2, simulation environments (Gazebo, Isaac Sim), and deep learning frameworks for robotics tasks.
4. Introduce foundation models, Vision-Language-Action (VLA) models, and LLM-driven task planning for next-generation intelligent robots.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Understand core AI and robotic system architectures including the perception-planning-actionlearning loop, robot kinematics, and sensor modalities.	L2	Understand
CO2	Apply deep learning, imitation learning, and reinforcement learning algorithms to solve robot navigation, manipulation, and control problems.	L3	Apply
CO3	Design, simulate, and evaluate robot systems using ROS2 or Gazebo, implementing AI perception and planning pipelines.	L6	Create
CO4	Apply foundation model-driven robotic systems using VLMs, VLAs, and LLM-based planners for open-vocabulary task execution.	L3	Apply

AI in Robotics (RCP23ACPE721)
Course Contents

Unit-I 08 Hrs.

Foundations of AI in Robotics: Evolution of robotics from rule-based automation to AI-driven autonomy, Robot taxonomy: industrial robots, mobile robots, humanoid robots, collaborative robots (cobots), drones, soft robots. Robot architecture: sensors (RGB, depth, LiDAR, IMU, force-torque, tactile), actuators, controllers, and end-effectors. Coordinate frames and transformations: homogeneous matrices, DH parameters, forward and inverse kinematics.

Unit-II 08 Hrs.

AI-Driven Robot Perception: Sensor modalities and their fusion: cameras, stereo depth, LiDAR point clouds, motion sensors. Classical computer vision for robotics: edge detection, feature extraction, optical flow, stereo matching. Deep learning for perception: CNN-based object detection, instance segmentation (Mask RCNN, SAM — Segment Anything Model). 3D perception: point cloud processing Semantic scene understanding: panoptic segmentation, 3D scene graphs, Tools: OpenCV, Open3D, PyTorch3D, ROS2 perception packages

Unit-III 07 Hrs.

Robot Motion Planning and AI-Augmented Control: Configuration space and robot motion basics, Configuration space (C-space), workspace analysis, degrees of freedom, and motion constraints. Classical path planning algorithms: Dijkstra, A*. AI-augmented planning: neural motion planners, learned heuristics for search, neural C-space representations. Introduction to PID control theory for robots. Learning-based control: neural network controllers, residual learning, adaptive control. Trajectory optimization, Robot manipulation and pick-and-place concepts. Manipulation planning..

Unit-IV 07 Hrs.

Machine Learning and Deep Reinforcement Learning for Robotics: Supervised learning in robotics: regression for dynamics models, classification for perception tasks, anomaly detection. Imitation learning: behavioral cloning, Inverse Reinforcement Learning (IRL). Deep Reinforcement Learning (DRL) fundamentals: Markov Decision Processes (MDPs), Qlearning. Policy gradient methods: REINFORCE, Proximal Policy Optimization (PPO), Sim-to-real transfer: domain randomization, domain adaptation, reality gap analysis, AugGAN.

Unit-V 07 Hrs.

Foundation Models and Language-Driven Robotics: Foundation models for robotics: pre-training paradigms, zero-shot and few-shot generalization. Large Language Models (LLMs) for task planning: SayCan, Inner Monologue, Vision-Language Models (VLMs) for robot perception: CLIP, DINO v2. Vision-Language-Action (VLA) models: RT-1, RT-2. Diffusion models for robot learning: Diffusion Policy, 3D Diffusion Actor, BESO. Video Prediction models, UniSim. On-device deployment: model quantization, NVIDIA Jetson Orin, TensorRT, ROS2 integration with LLM APIs.

Unit-VI 05 Hrs.

Human-Robot Interaction, Safety, and Emerging Applications: Human-Robot Interaction (HRI): shared autonomy, teleoperation, adjustable autonomy, intent prediction. Natural language interfaces for robots: voice command systems, dialogue-based task specification, multimodal HRI. Robot safety: functional safety standards (ISO 10218, ISO/TS 15066), collision detection, force-limiting, safety-rated monitored stops, safe RL. Ethical and social dimensions: job displacement, autonomous weapons (LAWS), accountability, robot rights, bias in robotic systems. Applications of AI robots in healthcare, industry, and autonomous systems. Future trends in humanoid and embodied AI robots.

AI in Robotics Laboratory (RCP23ALPE721)
List of Laboratory Experiments (Any 10)

1. Set up Stable Baselines3 OR ROS2 (Humble/Jazzy) environment; create publisher-subscriber nodes and simulate a mobile robot in Stable Baselines3 OR Gazebo
2. Implement forward and inverse kinematics for a 3-DOF robotic arm using Python and visualize with RViz2
3. Perform real-time object detection using YOLOv8 on a camera feed and publish detected object poses over Stable Baselines3 /ROS2 topics
4. Build a 2D occupancy grid map using LiDAR data in Stable Baselines3 /Gazebo and implement A* path planning for navigation
5. Implement feature-based visual odometry using ORB keypoint matching and estimate robot trajectory from image sequences
6. Train a CNN to classify objects in a robot workspace and integrate the model with a ROS2 perception node
7. Implement a PID and MPC controller for a differential-drive robot to follow a given trajectory in simulation
8. Train a Deep Q-Network (DQN) agent for obstacle-avoidance navigation in a 2D grid environment using OpenAI Gymnasium
9. Train a PPO agent for robotic arm reaching and manipulation using Stable-Baselines3 and PyBullet
10. Apply Behavioral Cloning (imitation learning) from human demonstrations to teach a simulated robot a pick-and-place task
11. Implement domain randomization (textures, lighting, dynamics) in Isaac Sim and evaluate sim-to-real transfer performance
12. Use CLIP and Grounded-SAM for language-guided object picking: specify target object in natural language, robot picks it
13. Integrate an LLM (via OpenAI API) for high-level natural language task decomposition and execute steps on a simulated robot
14. Mini project: Build a complete AI robotic pipeline — perception (YOLOv8), path planning (RRT*), LLM task planning, and manipulation execution in a Stable Baselines3 /ROS2-Gazebo environment

Text Books:

1. Peter Corke, "Robotics, Vision and Control: Fundamental Algorithms in Python", 3rd ed., Springer, 2023.
2. Bruno Siciliano, Lorenzo Sciavicco et al., "Robotics: Modelling, Planning and Control", Springer, 2010.
3. Pieter Abbeel, Chelsea Finn, Sergey Levine, "Robot Learning — Foundations and Modern Approaches", UC Berkeley Lecture Notes, 2024.

Reference Books:

1. Lentin Joseph, "Robot Operating System (ROS) for Absolute Beginners", 2^{nd} ed., Apress, 2022.
2. Michael Lanham, "Hands-On Deep Learning for Games", Packt, 2019. (Chapters on RL for robotics and simulation)

NPTEL Courses:

1. Introduction to Robotics https://onlinecourses.nptel.ac.in/noc22_me97/preview
2. Robot Mechanics and Control https://onlinecourses.nptel.ac.in/noc23_me65/preview
3. Deep Learning for Computer Vision https://onlinecourses.nptel.ac.in/noc22_cs92/preview
4. Reinforcement Learning https://onlinecourses.nptel.ac.in/noc24_cs58/preview
5. Introduction to Machine Learning https://onlinecourses.nptel.ac.in/noc23_cs86/preview
6. Modern Robotics: Mechanics, Planning, and Control Specialization
   https://www.coursera.org/specializations/modernrobotics
7. AI for Robotics https://www.coursera.org/learn/packt-artificial-intelligence-for-robotics

Program: Artificial Intelligence and Machine Learning	Final Year B.Tech.	Semester: VII
Quantum Computing (RCP23ACPE722)		
Quantum Computing Laboratory (RCP23ALPE722)		

Pre-requisite: Statistics for Data Science, and Machine Learning – I.

Course Objective(s):

To equip students with foundational and practical knowledge of quantum computing, enabling them to understand quantum principles, analyze quantum algorithms, and apply quantum tools for solving computational problems.

Course Outcomes: On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Explain the basic principles and mathematical foundations of quantum computing including qubits, superposition, and entanglement.	L2	Understand
CO2	Analyze and construct quantum circuits for various quantum operations.	L4	Analyze
CO3	Demonstrate applications of key quantum algorithms such as Deutsch-Jozsa, Grover's, and Shor's.	L3	Apply
CO4	Apply quantum cryptographic protocols like BB84 and analyze their security features.	L3	Apply
CO5	Evaluate the effects of quantum error correction and noise models in computations.	L5	Evaluate
CO6	Use industry-standard quantum programming platforms (e.g., Qiskit) to design, simulate, and test quantum algorithms.	L3	Apply

Quantum Computing (RCP23ACPE722)
Course Contents

Unit-I 07 Hrs.

Fundamentals of Quantum Computing and Qubits: Introduction to Quantum Computing, Limitations of Classical Computing, Classical Bits vs Quantum Bits (Qubits), Basic Concepts of Quantum Mechanics, Quantum States, Superposition, Measurement, Representation of Qubits, Bloch Sphere Representation, Basic Mathematical Concepts, Complex Numbers, Vectors and Matrices.

Unit-II 07 Hrs.

Qubits and Multi-Qubit Systems: Quantum Gates and Their Functions, Single Qubit Gates- Pauli-X Gate, Pauli-Y Gate, Pauli-Z Gate, Hadamard Gate, Phase Gate, Rotation Gate Multi-Qubit Systems - Tensor Product Concept, Controlled Gates, CNOT Gate, SWAP Gate, Toffoli Gate. Quantum Entanglement, Bell States, No-Cloning Theorem.

Unit-III 06 Hrs.

Quantum Programming and Simulation: Introduction to Quantum Programming, Quantum Programming Platforms: Qiskit, Cirq, PennyLane. , Installing and Setting Up Quantum Environment, Writing Basic Quantum Programs, Quantum Circuit Simulation, Running Quantum Programs on Simulators, Visualization of Quantum States, Introduction to Quantum Cloud Platforms

Unit-IV 08 Hrs.

Quantum Algorithms: Introduction to Quantum Algorithms, Concept of Quantum Speedup Quantum Oracles and Query Model, Deutsch Algorithm, Deutsch– Jozsa Algorithm, Bernstein–Vazirani Algorithm, Simon's Algorithm Quantum Fourier Transform (QFT), Phase Estimation Algorithm, Shor's Algorithm (Quantum Factoring), Grover's Search Algorithm, Applications of Quantum Algorithms.

Unit-V 07 Hrs.

Quantum Communication and Quantum Cryptography: Introduction to Quantum Communication, Principles of Quantum Cryptography, Quantum Key Distribution (QKD), BB84 Protocol, Quantum Teleportation, Superdense Coding, Quantum Communication Networks, Security of Quantum Communication, Applications of Quantum Cryptography.

Unit-VI 07 Hrs.

Quantum Error Correction and Advanced Applications: Introduction to Quantum Errors and Noise, Sources of Errors in Quantum Systems, Quantum Error Correction Concepts, Bit-Flip and Phase-Flip Errors, Shor Code and Steane Code, Fault-Tolerant Quantum Computing, NISQ (Noisy Intermediate-Scale Quantum) Computing, Variational Quantum Algorithms (VQE, QAOA), Introduction to Quantum Machine Learning Applications of Quantum Computing: Optimization, Artificial Intelligence, Chemistry, Finance.

Quantum Computing Laboratory (RCP23ALPE722)
List of Laboratory Experiments (Any 10)

1. Prepare single and multi-qubit quantum states (superposition, entangled states, Bell states)
2. Visualizing qubit and multi-qubit states on the Bloch sphere Observing the effects of various quantum gates on qubits
3. Implementation and experimental testing of basic gates (Pauli-X, Y, Z, Hadamard, Phase, CNOT, Toffoli, SWAP)
4. Deutsch and Deutsch-Jozsa algorithms: distinguishing between constant and balanced functions
5. Grover's search algorithm: amplitude amplification and unstructured search
6. Simon's algorithm: finding a secret string with exponential speedup
7. Shor's algorithm (simulation): factoring small integers
8. Preparation, measurement, and verification of Bell states and entanglement
9. Assignments on BB84 quantum key distribution protocol Analysis of quantum eavesdropping and protocol robustness
10. Implementation of three-qubit bit-flip and phase-flip error correction codes
11. Implement and benchmark quantum key distribution protocols (BB84, E91) on quantum networks to advance secure access for underserved populations. (SDG-9)
12. Implement and compare quantum support vector machines (QSVM) or quantum k-nearest neighbors (QkNN)
13. Demonstrate quantum teleportation across chained entangled qubit pairs or quantum repeater simulation
14. Compare performance of different quantum compiler tools (Qiskit, Cirq, PennyLane) on non-trivial circuits.

Text Books:

1. Michael A. Nielsen and Isaac L. Chuang, Quantum Computation and Quantum Information, 10th Anniversary Edition, Cambridge University Press, 2010.
2. Phillip Kaye, Raymond Laflamme, and Michele Mosca, An Introduction to Quantum Computing, 1st Edition, Oxford University Press, 2007.
3. Eleanor G. Rieffel and Wolfgang H. Polak, Quantum Computing: A Gentle Introduction, 1st Edition, MIT Press, 2011.

Reference Books:

1. Noson S. Yanofsky and Mirco A. Mannucci, Quantum Computing for Computer Scientists, 1st Edition, Cambridge University Press, 2008.
2. Robert S. Sutor, Dancing with Qubits: How Quantum Computing Works and How It Can Change the World, 1st Edition, Packt Publishing, 2019.

3. Ivan B. Djordjevic, Quantum Information Processing, Quantum Computing and Quantum Error Correction: An Engineering Approach, 2^{nd} Edition, Elsevier (Academic Press), 2021.duction", MIT Press, 2011.

Web Links:

1. Web resources: IBM Quantum Learning: https://quantum.cloud.ibm.com/learning MIT xPRO Quantum Computing Fundamentals: https://learnxpro. mit.edu/quantum-computing
2. Online Courses: NPTEL / Swayam :
    2. Introduction to Quantum Computing course: https://onlinecourses.nptel.ac.in/noc25_cs95/preview.
    2. Coursera Quantum Computing course: https://www.coursera.org/learn/quantum-computing

Program: Artificial Intelligence and Machine Learning	Final Year B. Tech	Semester: VII
High Performance Computing (RCP23ACPE723)		
High Performance Computing Laboratory (RCP23ALPE723)		

Pre-requisite: System Fundamentals, C/C++ programming, Data Structures.

Course Objective(s):

1. To learn concepts of parallel processing as it pertains to high-performance computing.
2. To design, develop and analyze parallel programs on high performance computing resources using parallel programming paradigm

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Apply GPU architecture concepts and the CUDA programming model to address parallel programming challenges in heterogeneous systems.	L3	Apply
CO2	Implement CUDA C programs to solve data parallelism problems and use CUDA memory models effectively.	L3	Apply
CO3	Analyze GPU performance metrics, including memory coalescing, thread scheduling, and control divergence impacts.	L4	Analyze
CO4	Assess different GPU computing frameworks and libraries (cuBLAS, cuDNN) based on application requirements and efficiency.	L5	Evaluate

High Performance Computing (RCP23ACPE723)
Course Contents

Unit-I Introduction to Parallel Processing 08 Hrs.

Sequential vs parallel computing, Need and applications of parallel computing, parallel computing architectures – shared memory and distributed memory, Flynn's taxonomy, Limitations of single core CPU, Multi-core CPU architecture. Performance Metrics in parallel computing – Speedup, Efficiency, scalability, Amdahl's law.

Unit-II CUDA Parallelism Model 08 Hrs.

Introduction: Architecture of A Modern GPU, Challenges in Parallel Programming, Parallel Programming Languages and Models. **Data Parallelism:** Data Parallelism, CUDA C Program Structure, A Vector Addition Kernel, Device Global Memory and Data Transfer, Kernel Functions and Threading, Kernel Launch. **Scalable Parallel Execution:** CUDA Thread Organization, Mapping Threads To Multidimensional Data, Synchronization And Transparent Scalability, Resource Assignment, Thread Scheduling And Latency Tolerance.

Unit-III Performance Considerations On GPUs: 08 Hrs.

Memory Access Performance:

Global Memory Bandwidth, Memory Coalescing in CUDA, Channels and Banks in Dram Systems, Techniques For Reducing Memory Transfers Between CPU And GPU. **Memory And Data Locality:** CUDA Memories, Tiled Parallel. Algorithms, Tiled Matrix Multiplication, Tiled Matrix Multiplication Kernel, Boundary Checks, Memory As A Limiting Factor To Parallelism. **Thread Execution Efficiency:** Warps And SIMD Hardware, Dynamic Partitioning Of Resources, Performance Impact Of Control Divergence.

Unit-IV 08 Hrs.

Parallel Patterns:Convolution:

1d Parallel Convolution—A Basic Algorithm, Constant Memory and Caching, Tiled 1d Convolution with Halo Cells, A Simpler Tiled 1d Convolution—General Caching. **Parallel Computation Patterns (Histogram):** Atomic Operations in CUDA, Atomic Operation Performance-Block versus Interleaved Partitioning, Latency versus Throughput of Atomic Operations, Atomic Operation in Cache Memory, Privatization Technique For Improved Throughput.

Unit-V Performance Optimization on GPUs 04 Hrs.

Efficient Host-Device Data Transfer:

Pinned Host Memory, Task Parallelism in CUDA, Overlapping Data Transfer with Computation, CUDA Unified Memory. **Techniques for optimizing GPU performance:** warp divergence, loop unrolling, vectorization, Memory bandwidth optimization techniques, Advanced GPU programming concepts (shared memory atomics, warp shuffling).

Unit-VI Advanced Topics & AI Integration 06 Hrs.

Introduction to GPU accelerated libraries (cuBLAS, cuDNN, cuGraph). Machine Learning Implementation: Reduction of Convolutional Layers to Matrix Multiplication, and a basic CUDA implementation of Forward Propagation. Integration with TensorFlow/PyTorch. Introduction to GPU clusters and distributed GPU computing.

High Performance Computing Laboratory (RCP23ALPE723)
List of Laboratory Experiments (Any 10)

1. Set up the CUDA environment and write a basic "Hello World" kernel.
2. Implement Vector Addition to master thread management and GPU memory allocation.
3. Develop an optimized Tiled Matrix Multiplication kernel using Shared Memory.
4. Apply CUDA for Image Processing (Blurring/Edge Detection).
5. Implement Parallel Reduction (Sum/Min/Max) to grasp efficient collective operations.
6. Explore Parallel Sorting Algorithms and compare GPU vs. CPU performance.
7. Employ CUDA for Monte Carlo Simulations to estimate mathematical constants.
8. Implement Concurrent Data Structures using locks and atomic operations.
9. Optimize reduction steps using Warp Shuffling and Privatization techniques.
10. Implement a Convolutional Layer Forward Propagation kernel using CUDA/cuDNN.
11. Perform Log Analysis-Based Resource and Execution Time Improvement.
12. Analyze Memory Coalescing and Control Divergence using GPU Profiling tools.
13. Implement 1D Parallel Convolution using Constant Memory and Caching.
14. Accelerate Graph Analytics (PageRank/BFS) using the cuGraph library.
15. Implement Task Parallelism and Data Overlap using CUDA Streams and Unified Memory.

Text Books:

Core HPC & Cloud Computing:

1. Edson Borin et al., "High Performance Computing in Clouds: Moving HPC Applications to a Scalable and Cost-Effective Environment", Springer 2023.
2. Robert Robey & Yuliana Zamora, "Parallel and High Performance Computing", Manning Publications 2021.
3. Georg Hager & Gerhard Wellein, "Introduction to High Performance Computing for Scientists and Engineers", CRC Press 2019.
4. Charles Severance & Kevin Dowd, "High Performance Computing", O'Reilly Media, 2nd Edition.
5. Christian Vecchiola et al., "High-Performance Cloud Computing: A View of Scientific Applications", IEEE 2009.

GPU & CUDA Programming:

1. David B. Kirk & Wen-mei W. Hwu, "Programming Massively Parallel Processors: A Hands-on Approach", Morgan Kaufmann, 4th Edition 2022.
2. Richard Ansorge, "Programming in Parallel with CUDA", Cambridge University Press 2022.
3. Jason Sanders & Edward Kandrot, "CUDA by Example: An Introduction to General-Purpose GPU Programming", Addison-Wesley.

4. Duane Storti & Mete Yurtoglu, "CUDA for Engineers: An Introduction to High-Performance Parallel Computing", Addison-Wesley 2016.

AI & Specialized Applications:

1. Alexander Heifetz, "High Performance Computing for Drug Discovery and Biomedicine", Springer Nature 2023.
2. Brian Tuomanen, "Hands-On GPU Programming with Python and CUDA", Packt Publishing 2018.
3. Brian Tuomanen, "Deep Learning with CUDA", O'Reilly Media.

Reference Books:

1. David B. Kirk and Wen-mei W. Hwu, Morgan Kaufmann, "Programming Massively Parallel Processors: A Handson Approach", 4^{th} Edition, 2022.
2. Jason Sanders and Edward Kandrot, "CUDA by Example: An Introduction to General-Purpose GPU Programming", Addison-Wesley, 1^{st} Edition, 2010.
3. Hager, G. and Wellein, G, "Introduction to High Performance Computing for Scientists and Engineers", CRC Press, ISBN-13 9781439811931, 2010.
4. "High Performance Computing For Dummies", Sun and AMD Special Edition, Douglas Eadline Wiley Publishing, Inc., 2009.
5. Catherine Régis, Jean-Louis Denis, Maria Luciana Axente, and Atsuo Kishimoto, "Human- Centered AI: A Multidisciplinary Perspective for Policy-Makers, Auditors, and Users", CRC Press 2024.

NPTEL and Coursera Courses::

Course Code	**Course Name**	**Institute / Instructor**	**Link**
noc20_me65	High Performance Computing	Prof. Somnath Roy / IIT Kharagpur	nptel.ac.in/courses/112105293
noc21_cs82	Multi-Core Computer Architecture - Storage and Interconnects	Prof. John Jose / IIT Guwahati	Preview: Multi-Core Computer Architecture – Storage and Interconnects — SWAYAM
noc22_cs110	Multi-Core Computer Architecture - Storage and Interconnects	Prof. John Jose / IIT Guwahati	Preview: Multi-Core Computer Architecture – Storage and Interconnects — SWAYAM
Coursera	Introduction to High Performance and Parallel Computing	University of Colorado Boulder	Introduction to High- Performance and Parallel Computing — Coursera

Program: Artificial Intelligence and Machine Learning	Final Year B.Tech.	Semester: VII
Cloud Computing (RCP23ACMD701)		
Cloud Computing Laboratory (RCP23ALMD701)		

Pre-requisite: Computer Networks, Operating Systems & Linux Basics, Database Management Systems.

Course Objectives:

1. To familiarize with modern cloud computing deployment topologies and containerization frameworks.
2. To gain hands-on experience in programmatically provisioning cloud resources using Infrastructure as Code (IaC).
3. To introduce the best practices for securing cloud services, implementing FinOps cost controls, and managing access rules.
4. To introduce modern serverless application design patterns and distributed observability techniques.

Course Outcomes: On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Formulate resilient cloud architecture patterns utilizing public, private, and hybrid cloud models.	L6	Create
CO2	Programmatically provision, version, and manage multi-tier cloud networks using declarative IaC tools.	L5	Evaluate
CO3	Apply modern Identity and Access Management (IAM), FinOps, and DevSecOps security guardrails.	L3	Apply
CO4	Architect, containerize, scale, and monitor distributed microservices and serverless workloads.	L5	Evaluate

Cloud Computing (RCP23ACMD701)
Course Contents

Unit-I Cloud Architecture Foundations & Evolution 04 Hrs.

Overview of cloud computing evolution from distributed and grid paradigms to Cloud-Native architectures, Fundamentals of cloud computing ecosystem and core characteristics, Cloud service models: IaaS, PaaS, SaaS, Core cloud services: compute, storage, object/block/file storage, databases, load balancers, DNS, queues, and autoscaling, Hypervisors vs. Container Virtualization, Cloud Global Infrastructure (Regions, Availability Zones, and Edge Locations)

Unit-II Infrastructure as Code (IaC) Cloud Provisioning 05 Hrs.

Declarative vs. Imperative cloud provisioning, Idempotency and configuration drift, Infrastructure state management, remote backends, and concurrency state locks, Modular infrastructure architecture, Cloud networking layouts (VPCs, Public/Private subnets, Route Tables, and NAT Gateways).

Unit-III Containerization & Cloud-Native Orchestration: 06 Hrs.

Monolithic to Microservices application migration patterns, Open Container Initiative (OCI) standards, Container networking interfaces (CNI) and storage volumes (CSI), Declarative container orchestration systems, Pod lifecycle and resource scheduling, Cloud deployment strategies (Rolling updates, Blue-Green, and Canary deployments).

Unit-IV Serverless Computing Event-Driven Architectures 04 Hrs.

Overview of serverless computing and execution patterns, Micro-VM architectures and execution lifecycle, Optimizing cold starts vs. warm starts, Managed cloud notification services and event queues, Decoupled event producers, routers, and event consumers.

Unit-V Cloud Security, FinOps & Site Reliability: 05 Hrs.

Securing the Cloud, the shared responsibility model, Managing the cloud security service boundary, Identity and Access Management (IAM), Least Privilege Principle and Role-Based Access Control (RBAC), Automated DevSecOps compliance and vulnerability scanning, Introduction to FinOps frameworks (Cloud cost auditing, right-sizing resources, and cost prediction).

Unit-VI Edge Computing, CDN & Hybrid Cloud Deployment: 04 Hrs.

Evolution from centralized cloud computing to distributed, Edge and Fog topologies, Cloud-to-Edge architectural frameworks, Content Delivery Networks (CDNs), edge caching mechanics, and edge compute functions, Hybrid cloud infrastructure patterns, Introduction to Edge AI/ML deployment considerations (hardware optimization, latency constraints, and dynamic data synchronization).

Cloud Computing Laboratory (RCP23ALMD701)
List of Laboratory Experiments (Any 10)

1. Local Cloud Simulation Environment: Configure a local, emulated AWS environment using LocalStack and MinIO to interact with mock cloud storage via the AWS-CLI.
2. Declarative Cloud Network Design: Write and validate a declarative Terraform script to provision a secure VPC with segregated Public/Private subnets.
3. Stateful Infrastructure Controls: Implement automated state locking mechanisms using local backend databases to safely manage team-based infrastructure modifications.
4. Production-Ready Application Packaging: Develop optimized, multi-stage Docker configurations to package web microservices securely under non-root permissions.
5. Microservices Deployment Orchestration: Write declarative Kubernetes manifests to deploy multi-tier microservice workloads featuring localized configuration variables.
6. Cloud Auto-Scaling and Self-Healing Automation: Implement a Kubernetes Horizontal Pod Autoscaler (HPA) and run synthetic stress testing to watch automated scheduling response.
7. Serverless Event Hooks: Code and run an asynchronous background compute function triggered autonomously by an object storage file upload event.
8. DevSecOps Pipeline Integration: Build automated configuration linters using Trivy and Checkov to catch security holes and hidden hardcoded tokens before deployment.
9. FinOps Financial Forecasting: Configure Infracost scripts within a local repository to output a estimated monetary variance report on infrastructure modifications.
10. Edge CDN Caching & Header Optimization. Deploy an application backend and configure a Content Delivery Network (CDN) layer (using an emulator or Cloudflare/CloudFront free tier).
11. Containerized Edge AI Inference Deployment: Package a lightweight, pre-trained AI/ML inference model (like a mobile computer vision or NLP model) into a highly optimized Docker container. Restrict the container's CPU/RAM programmatically to simulate a low-power edge gateway/device and test its latency limits.
12. Live Multi-Tier Cloud Deployment: Launch a fully secure and functional runtime application stack on cloud free tiers.
13. Continuous Integration & Automation Pipelines (CI/CD): Construct a GitHub Actions pipeline that triggers formatting checks, unit assessments, and automated updates to cloud environments.
14. Resilience Verification via Chaos Testing: Inject artificial performance degradation and instance terminations to evaluate real-time self-healing capabilities.

Self-learning topics:

1. Linux Terminal Basics & Essential SSH Commands
2. Basic Git Commands & Code Repository Management
3. Real-World Cloud Deployment Frameworks (Conceptual case studies of Public, Private, and Hybrid implementations).

Text Books:

1. Yevgeniy Brikman, "Terraform: Up & Running: Writing Infrastructure as Code", 3rd Edition, O'Reilly Media, 2023.
2. Brendan Burns, Joe Beda, and Kelsey Hightower, "Kubernetes: Up and Running", 3rd Edition, O'Reilly Media, 2022.
3. Arshdeep Bahga and Vijay Madisetti, "Cloud Computing: A Hands-On Approach", 1st Edition, VPT/Universities Press, 2014.

Reference Books:

1. Justin Garrison and Kris Nova, "Cloud Native Infrastructure: Patterns for Scalable Infrastructure and Applications", 1st Edition, O'Reilly Media, 2017.
2. Thomas Erl, Ricardo Puttini, and Zaigham Mahmood, "Cloud Computing: Concepts, Technology & Architecture", 1st Edition, Pearson Education, 2013.
3. Betsy Beyer, Chris Jones, Jennifer Petoff, and Niall Richard Murphy, "Site Reliability Engineering: How Google Runs Production Systems", 1st Edition, O'Reilly Media, 2016.

NPTEL and Coursera Courses::

Course Code	**Course Name**	**Institute / Instructor**	**Link**
noc23_cs42	Cloud Computing	Prof. Soumya Kanti Ghosh (IIT Kharagpur)	https://nptel.ac.in/courses/106105167
noc24_cs115	Google Cloud Computing Foundations	Joint Course by NPTEL and Google Cloud Team	https://nptel.ac.in/courses/106105223
noc22_cs90	Multi-Core Computer Architecture: Storage and Interconnects	Prof. John Jose / IIT Guwahati	https://nptel.ac.in/courses/106103183
Coursera	Introduction to Cloud Computing	IBM	https://www.coursera.org/learn/introduction-to-cloud
Coursera	Architecting with Google Compute Engine Specialization	Google	https://www.coursera.org/specializations/gcp-architecture
Coursera	Introduction to Microsoft Azure Cloud Services	Microsoft	https://www.coursera.org/learn/microsoft-azure-cloud-services

Program: Artificial Intelligence and Machine Learning	Final Year B. Tech	Semester: VII
Research Ecosystem (RCP23ITELX08)		

Pre-requisite:

1. Basic understanding of Engineering concepts and problem-solving techniques.
2. Fundamental knowledge of project-based learning, data analysis, and domain-specific tools.
3. Basic exposure to project development, technical report writing, and emerging technologies.

Course Objectives:

1. To understand and identify complex engineering, societal, and industrial problems suitable for research through structured analysis of literature, patents, and real-world needs.
2. To learn and apply advanced research methodologies—including experimental, simulation based, and data-driven approaches—for designing and validating engineering solutions.
3. To gain proficiency in selecting and using appropriate tools, software, and platforms (AI/ML, simulation, CAD, IoT, etc.) for experiment design, data acquisition, and performance evaluation.
4. To transform research insights into innovative prototypes, products, or startup concepts by engaging with innovation ecosystems, TRLs, and funding mechanisms.
5. To analyze socio-technical systems, ethics, and sustainability implications of engineering solutions, ensuring responsible and impactful outcomes.
6. To integrate systems thinking, multidisciplinary perspectives, policy awareness, future technology trends, and technical documentation skills to develop comprehensive research proposals and outputs (papers, patents, reports).

Course Outcomes: On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Analyze complex engineering and societal problems to evaluate literature and patents and formulate clear research gaps.	L4	Analyze
CO2	Apply advanced research methods and tools to acquire data and evaluate solution performance.	L3	Apply
CO3	Apply innovation frameworks and Technology Readiness Levels.	L3	Apply
CO4	Analyze ethical, socio-technical, and sustainability issues and create responsible engineering solutions.	L4	Analyze
CO5	Analyze multidisciplinary knowledge to create research proposals and scalable, future-ready solutions.	L4	Analyze

Research Ecosystem (RCP23ITELX08)
Course Contents

Unit-I Research Gap Identification & Problem Formulation 05 Hrs.

Identifying high-impact problems from:

- Industry and Society
- Emerging technologies (AI, IoT, Blockchain, EV, etc.)

Research gap identification techniques:

- Systematic Literature Review (SLR)
- Patent analysis

Defining objectives, scope, constraints, and feasibility of the identified problem Writing problem statement for:

- Research paper
- Product/Startup idea

Activities:

- Convert Industry/ Societal problem into research problem.
- Analyze research articles and extract research gaps.

Unit-II Experimental Design, Tools & Validation Techniques 06 Hrs.

Advanced research methodologies:

- Experimental, simulation, data-driven, design thinking

Tool selection:

- Computational tools and software, simulation and analysis platforms, system prototyping and testing platforms

Data acquisition:

- Data collection interfaces, Principles of data cleaning and organization (primary / secondary data)

Validation techniques:

- Accuracy and performance metrics
- Benchmarking with existing solutions

Result interpretation & visualization

Activities:

- Selection of Research Design for final year project.
- Apply evaluation metrics (e.g., ML model accuracy, system efficiency).

Unit-III Research to Innovation, Product & Startup Ecosystem 05 Hrs.

Research → Prototype → Product → Startup lifecycle

Intellectual Property Rights (IPR), patents, copyrights

Technology readiness levels (TRL)

Case studies:

- AI startups, EV ecosystem, Smart Cities

Industry-academia collaboration models

Funding opportunities (grants, incubation, government schemes - Anusandhan National Research Foundation (ANRF))

Activities:

- Convert project into startup idea or product pitch.
- Analyze failure of a technology/product.

Unit-IV Socio-Technical Systems, Ethics & Sustainability 06 Hrs.

Socio-technical systems: Interaction of people, technology and environment

Ethical issues:

- Plagiarism, AI bias, data privacy

Sustainability in Engineering:

- Green practices, resource optimization and lifecycle considerations

Impact assessment:

- Social, economic, environmental

Policies and governance (data protection laws, standards and compliance requirements)

Activities:

- Case study: Facial recognition ethics, smart surveillance.
- Impact analysis of student's own project.

Unit-V Integrated Research, Proposals and Future Engineering Challenges 06 Hrs.

Systems thinking and holistic analysis

Multidisciplinary problem solving:

- Healthcare tech., climate tech., smart mobility

Writing research proposals:

- Problem → Methodology → Expected outcomes

Future trends:

- AI ethics, Quantum computing, Industry 5.0 / 6.0

Scaling solutions from lab to society

Activities:

- Capstone Task:
  - Identify real-world problem.
  - Apply research methodology.
  - Propose:
    - Technical solution
    - Societal impact
    - Possible commercialization
- Impact analysis of student's own project.

Term Work Guidelines:

The Term Work (TW) shall consist of continuous assessment based on tutorials activities and a final group presentation.

1. Part A (25 Marks):
   Each student shall complete a minimum of five tutorials based on the syllabus topics during the semester. The tutorials may include activities such as research gap identification, literature survey, case study analysis, tool-based experimentation, impact analysis, technical report writing, and innovation-oriented problem solving.
2. Part B (25 Marks):
   Students shall work in groups and select a project/research topic based on emerging engineering, industrial, or societal challenges.
   The group presentation shall include:
   - Identification of a real-world problem
   - Application of appropriate research methodology
   - Proposed technical solution
   - Analysis of societal impact
   - Possible commercialization/startup opportunities

Reference Books:

1. Kothari, C. R., Research Methodology: Methods and Techniques, New Age International Publishers, New Delhi, 2023.
2. Booth, W. C., Colomb, G. G., Williams, J. M., Bizup, J., FitzGerald, W. T., The Craft of Research, University of Chicago Press, Chicago, 2024.
3. Montgomery, D. C., Design and Analysis of Experiments, Wiley, New York, 2020.
4. Singh, Pooja, Katiyar, Aman, Rawat, Shalini, Dhuri, Archana, Research Methodology and IPR, RK Publications, India, 2025.

5. Blok, Vincent (Ed.), Putting Responsible Research and Innovation into Practice: A Multi Stakeholder Approach, Springer Cham, Switzerland, 2022.

Web References:

1. Research Methodology: Quantitative Methods and Computer Application (https://onlinecourses.swayam2.ac.in/e-learning/preview/ini26_ma02)
2. Research Methodology and IPR (https://onlinecourses.swayam2.ac.in/e-learning/preview/ntr26_ed28)
3. Research and Publication Ethics (https://onlinecourses.swayam2.ac.in/e-learning/preview/nou26_ge46)
4. Research Ethics and Plagiarism (https://onlinecourses.swayam2.ac.in/e-learning/preview/nou26_ge26)
5. Quantitative and Mixed Methods Research for Management (https://onlinecourses.swayam2.ac.in/e-learning/preview/imb26_mg21)
6. Doing Qualitative Research (https://onlinecourses.swayam2.ac.in/e-learning/preview/nou26_ge61) .

Program: Artificial Intelligence and Machine Learning	Final Year B. Tech	Semester: VII
Project Stage-II (RCP23IPEL701)		

Course Objectives:

1. To implement the solution as per the problem statement.
2. To develop the team building, writing, logical reasoning and management skills.
3. To provide the connections between the designs and concepts across different disciplinary boundaries.
4. To encourage students to become independent personnel, critical thinkers and lifelong learners

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Apply engineering knowledge to produce solution of a prob- lem considering cultural, social, environmental, and economic factors using appropriate tool and method.	L4	Analyze
CO2	Demonstrate project based learning that allows students to transfer existing ideas into new applications.	L2	Understand
CO3	Develop an ability to work in teams and manage the conduct of the research study.	L3	Apply
CO4	Integrate different perspectives from relevant disciplines which help them to get internships, jobs and admission for higher studies.	L3	Apply
CO5	Present the research in the form of technical writing, under- stand what constitutes to plagiarism and how to use proper referencing styles.	L2	Understand

Syllabus:

Project-I work done in VI semester shall be continued as Project-II in semester VII.

Students should complete remaining implementation of ideas given in synopsis/Abstract of semester VI.

Students / group must plan their execution of project, so that project work should be completed before end of semester.

Project-II involves fabrication, design, experimentation, data analysis within realistic constraints such as economic, environmental, social, ethical, health and safety, manufacturability, and sustainability. The stage also includes testing, possible results and report writing.

Each project group is required to maintain log book for documenting various activities of Project-II and submit group project report at the end of Semester-VII in the form of Hard bound.

Domain knowledge (any beyond) needed from the various areas in the field of AIML for the effective implementation of the project.

The above areas can be updated based on the technological innovations and development needed for specific project. **Guidelines:**

The main purpose of this activity is to improve the students' technical skills, communication skills by integrating writing, presentation and teamwork opportunities.

Each group will be reviewed twice in a semester and marks will be allotted based on the various points mentioned in the evaluation scheme.

In the first review of this semester, each group is expected to complete 70% of project.

In the second review of this semester, each group is expected to complete 100% of project.

The students may use this opportunity to learn different computational techniques towards development of a product.

Interaction with alumni mentor will also be appreciated for the improvement of project.

Assessment Criteria:

1. At the end of the semester, after confirmation by the project guide, each project group will submit project completion report in prescribed format for assessment to the departmental committee (including project guide).
2. Assessment of the project (at the end of the semester) will be done by the departmental committee (including project guide).
3. The candidate must bring the Project Stage-I report and the final report completed in all respect while appearing for End Semester Examination.
4. Oral examination should be conducted by Internal and External examiners. Students have to give presentation and demonstration based on their project.

Prescribed project report guidelines:

Every group should prepare hard bound report (preferrable LaTeX) of about minimum 40 pages on the work carried out by a batch of students in respect of the project work done during semester-VII. Project Report should include appropriate content for:

1. Title
2. Abstract
3. Introduction
4. Problem identification and project objectives
5. Literature Survey
6. Related Theory

7. Project design and Implementation details
8. Case study/Analysis/Design Methodology
9. Project Outcomes
10. Result and Conclusion
11. Future scope
12. References

Assessment criteria for the departmental committee (including project guide) for Continuous Assessment: Guide will monitor weekly progress and marks allocation will be as per Table 2.

Table 1: Log Book Format

Sr	**Week (Start Date:End Date)**	**Work Done**	**Sign of Guide**	**Sign of Coordinator**

Table 2: Continuous Assessment Table

Sr	**Exam Seat No**	**Name of Student**	**Student Attendance**	**Log Book Maintain**	**Literature Review**	**Depth of Understanding**	**Report**	**Total**
			5	5	5	5	5	25

Assessment criteria for the departmental committee (including project guide) for End Semester Exam: Each group will be reviewed twice in a semester by faculty guide and faculty coordinator based on the following criteria:

1. Project progress
2. Documentation/Technical paper writing
3. Key findings
4. Validation of results
5. Product Development

Each review consists of 25 marks. Average of the marks scored in both the two reviews will be considered for final grading. The final certification and acceptance of TW ensures the satisfactory performance on the above aspects.

Table 3: Evaluation Table

Sr	**Exam Seat No**	**Name of Student**	**Project Selection**	**Design/ Methodology**	**Fabrication/ Modeling/ Simulation**	**Result Verification**	**Presentation**	**Total**
			5	5	5	5	5	25

Program: Artificial Intelligence and Machine Learning	Final Year B. Tech	Semester: VIII
Disaster Management and Preparedness (RCP23ICHSX09)		

Course Objective(s):

1. To provide basic understanding of hazards, disasters and various types and categories of disaster occurring around the world.
2. To identify extent and damaging capacity of a disaster.
3. To study and understand the means of losses and methods to overcome /minimize it.
4. To understand roles and responsibilities of individual and various organizations during and after disaster.
5. To appreciate the significance of GIS, GPS in the field of disaster management.
6. To understand the emergency government response structures before, during and after disaster.

Course Outcomes: On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Apply disaster management principles & guidelines.	L3	Apply
CO2	Conduct risk assessments.	L3	Apply
CO3	Develop community awareness & participation.	L6	Create
CO4	Utilize Science & Technology tools (GIS, GPS).	L3	Apply
CO5	Prepare disaster management plans.	L6	Create

Disaster Management and Preparedness (RCP23ICHSX09)
Course Contents

Unit-I 06 Hrs.

Understanding Disasters & Hazards:

• Definition and types of disasters: Natural, Man-made and hybrid disasters, Study of Natural disasters: Flood, drought, cloud burst, Earthquake, Landslides, Avalanches, Volcanic eruptions, Mudflow, Cyclone, Storm, Storm Surge, climate change, global warming, sea level rise, ozone depletion etc. Study of Human/Technology Induced Disasters: Chemical, Industrial and Nuclear disasters, internally displaced persons, road and train accidents Fire Hazards, terrorism, militancy,

• Hazard & Vulnerability profiles of India (seismic zones, flood-prone areas).

• India's vulnerability to disasters, and the impact of disasters on National development.

Unit-II 06 Hrs.

Disaster Risk Reduction (DRR) & Mitigation:

• Disaster Management Cycle: Prevention, Mitigation, Preparedness, Response, Recovery. Need for disaster prevention and mitigation, mitigation guiding principles, challenging areas, structural and non-structural measures for disaster risk reduction.

• Risk Assessment & Vulnerability Analysis.

• Science & Technology: Use of information management, Geo informatics like RS, GIS, GPS and remote sensing mitigation measure.

Unit-III 04 Hrs.

Disaster Preparedness & Response:

• Preparedness Planning, Early Warning Systems (EWS), & Communication.

• Emergency Response: Search & Rescue, Logistics, Medical Aid.

• Psychological Response & Management (Trauma, Stress).

• Role of IT, Media, Govt., NGOs, & Community.

Unit-IV 04 Hrs.

Recovery, Rehabilitation & Reconstruction:

• Post-disaster damage assessment.

• Rehabilitation, Reconstruction, & Livelihood Restoration.

• Sanitation, Hygiene, & Waste Management.

Unit-V 04 Hrs.

Policy, Governance & Capacity Building:

• National Disaster Management Authority (NDMA) & Legislation.

• Institutional Mechanisms & Community Mobilization. Non-Structural Mitigation: Community based disaster preparedness, risk transfer and risk financing, capacity development and training, awareness and education, contingency plans.

Unit-VI 04 Hrs.

Case studies on disaster (National /International):

• Case study discussion of National Disasters: Tsunami (2004), Bhopal gas tragedy, Kerala and Uttarakhand flood disaster, 26th July 2005 Mumbai flood

• Case study discussion of International Disasters: Hiroshima – Nagasaki (Japan), Cyclone Phailin (2013), Fukushima, Daiichi nuclear disaster (2011), Chernobyl meltdown

Reference Books:

1. Harsh K. Gupta, "Disaster Management", Universities Press Publications, 2003.
2. O. S. Dagur, "Disaster Management: An Appraisal of Institutional Mechanisms in India", published by Centre for land warfare studies, New Delhi, 2011.
3. Damon Copolla, Butterworth Heinemann, "Introduction to International Disaster Management", Elsevier Publications, 2015.
4. Jack Pinkowski, CRC Press, "Disaster Management Handbook", Taylor and Francis group, 2008.
5. Rajdeep Dasgupta, "Disaster management & rehabilitation", Mittal Publications, New Delhi, 2007.
6. R B Singh, "Natural Hazards and Disaster Management, Vulnerability and Mitigation", Rawat Publications, 2006.
7. C. P. Lo Albert, K.W. Yonng, "Concepts and Techniques of GIS", Prentice Hall (India) Publications, 2006.
8. Claudia G. Flores Gonzales, "Risk management of natural disasters", KIT Scientific Publishing, 2010.
9. W. Nick Carter, "Disaster Management – a disaster manger's handbook", Asian Development Bank, 2008.
10. R. K. Srivastava, "Disaster Management in India", Ministry of Home Affairs, GoI, New Delhi, 2011.
11. Wil Mara, "The Chernobyl Disaster: Legacy and Impact on the Future of Nuclear Energy", Marshall Cavendish Corporation, New York, 2011.
12. Ronald Eisler, "The Fukushima 2011 Disaster", Taylor & Francis, Florida, 2013.

(Learners are expected to refer reports published at national and international level and updated information available on authentic web sites.)

Program: Artificial Intelligence and Machine Learning	Final Year B. Tech	Semester: VII
AI for Cybersecurity (RCP23ACSC701)		

Pre-requisite: Computer networks, basic cryptography, and Python data frameworks.

Course Objective(s):

1. Understand the fundamentals of Artificial Intelligence and Machine Learning in cybersecurity.
2. Apply AI techniques for threat detection, malware analysis, and network anomaly detection.
3. Utilize Generative AI and Large Language Models (LLMs) for cybersecurity operations.
4. Explore AI-assisted threat intelligence, incident response, and security automation.
5. Understand ethical, legal, and security challenges associated with AI in cybersecurity.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Explain the role of AI, ML, and Generative AI in cybersecurity.	L2	Understand
CO2	Apply machine learning techniques for threat detection and cyber defense.	L3	Apply
CO3	Analyze malware and network anomalies using AI-driven approaches.	L4	Analyzee
CO4	Use Generative AI tools for threat hunting, incident response, and security documentation.	L3	Apply
CO5	Demonstrate responsible and secure use of AI technologies in cybersecurity environments.	L3	Apply

AI for Cybersecurity (RCP23ACSC701)
Course Contents

Unit-I Introduction to AI for Cybersecurity: 05 Hrs.

Cybersecurity Landscape, Artificial Intelligence Fundamentals, Machine Learning Basics, Deep Learning Concepts, Generative AI and Large Language Models (LLMs), Applications of AI in Cybersecurity, AI-driven Security Operations Centers (SOC), Benefits, Challenges, and Limitations of AI in Security.

Unit-II Machine Learning for Threat Detection and Security Analytics: 05 Hrs.

Security Data Collection and Analysis, Security Logs and Event Data, Supervised and Unsupervised Learning for Cybersecurity, Intrusion Detection Systems (IDS), User and Entity Behavior Analytics (UEBA), Threat Detection Models, Security Analytics, AI-based Threat Intelligence, Performance Evaluation of Security Models.

Unit-III Advanced Malware and Network Anomaly Detection: 05 Hrs.

Malware Fundamentals, Static and Dynamic Malware Analysis, AI-based Malware Classification, Ransomware Detection, Malware Behavior Analysis, Network Traffic Analysis, Network Anomaly Detection Techniques, Deep Learning for Intrusion Detection, Detection of DDoS, Botnets and Advanced Persistent Threats (APT), Case Studies.

Unit-IV Generative AI for Cyber Defense and Responsible AI: 05 Hrs.

Prompt Engineering for Cybersecurity, AI-assisted Threat Hunting, Log Analysis using LLMs, Phishing Detection, Vulnerability Assessment, Incident Response Automation, Threat Intelligence Generation, Security Documentation and Reporting, Ethical AI, Adversarial AI, AI Risks and Hallucinations, AI Governance, Privacy and Future Trends in AI-driven Cybersecurity.

Online Course:

1. Introduction to AI for Cybersecurity:
   https://www.coursera.org/learn/introduction-to-ai-for cybersecurity
2. Artificial Intelligence for Cybersecurity:
   https://www.coursera.org/learn/packt-artificial intelligence-for-cybersecurity
3. Advanced Malware and Network Anomaly Detection Generative
   https://www.coursera.org/learn/advanced-malware-and-network-anomaly-detection
4. IBM AI for Cybersecurity Professionals Specialization:
   https://www.coursera.org/specializations/generative-ai-for-cybersecurity-professionals

Useful Courses:

1. Generative AI and its Impact on Cybersecurity –
   https://www.coursera.org/programs/nmims university-faculty-development-program-

kjd4b/learn/packt-generative-ai-and-its-impact-on cybersecurity-1ge45?authProvider=nmims&source=search

2. ChatGPT for Cybersecurity: AI Tools for Threat https://www.coursera.org/programs/nmims-university-faculty-development-program kjd4b/learn/packt-chatgpt-for-cybersecurity-ai-tools-for-threat-defense f7gee?authProvider=nmims&source=search

Artificial Intelligence and Machine Learning
Final Year B. Tech
2026-27
Semester - VIII

Program: Artificial Intelligence and Machine Learning	Final Year B. Tech	Semester: VIII
Responsible AI (RCP23ACPE811)		

Pre-requisite: Knowledge of AI

Course Objective(s):

1. Introduce the ethical, social, and legal dimensions of AI development and deployment across various domains.
2. Explore frameworks and methodologies for building fair, accountable, and transparent AI systems.
3. Provide hands-on experience with tools for bias detection, privacy preservation, and responsible AI evaluation.
4. Integrate responsible AI principles into the complete lifecycle of designing and deploying real-world AI applications.

Course Outcomes: On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Explain the core principles of AI ethics, including fairness, accountability, transparency, and privacy, and apply relevant governance frameworks.	L2	Understand
CO2	Apply bias detection and mitigation techniques using tools like AI Fairness 360, Fair learn, and SHAP to build equitable AI models.	L3	Apply
CO3	Apply privacy-preserving AI systems using differential privacy, federated learning, and data anonymization techniques.	L3	Apply
CO4	Use ethical governance frameworks and explainability methods into AI development pipelines for responsible, trustworthy, and accountable AI deployment.	L3	Apply

Responsible AI (RCP23ACPE811)
Course Contents

Unit-I Foundations of AI Ethics 07 Hrs.

History and evolution of AI ethics, Why ethics matters in AI: societal impact, economic implications, and human rights, Core principles: Fairness, Accountability, Transparency, Privacy, Non-maleficence, Beneficence, Autonomy, Ethical frameworks: Utilitarianism, Deontology, Virtue ethics applied to AI, AI ethics global frameworks: UNESCO Recommendation on AI Ethics, IEEE Ethically Aligned Design, EU AI Act principles, Stakeholder perspectives: developers, policymakers, users, and affected communities,

Unit-II Fairness, Bias, and Accountability in AI: 07 Hrs.

Types of bias: data bias, algorithmic bias, historical bias, representation bias, measurement bias, Fairness definitions and metrics: demographic parity, equalized odds, individual fairness, counterfactual fairness, Bias detection tools: IBM AI Fairness 360, Bias mitigation strategies: pre-processing (resampling, reweighting), in-processing (adversarial debiasing), post-processing (calibrated equalized odds), Accountability mechanisms: algorithmic auditing, AI impact assessments, human-in the-loop (HITL) systems, Responsibility frameworks: legal liability, corporate accountability, third-party auditing.

Unit-III Privacy, Data Ethics, and Security in AI 07 Hrs.

Privacy principles in AI: data minimization, purpose limitation, consent, data sovereignty, Data protection regulations: GDPR, Privacy-preserving ML techniques: differential privacy, federated learning, secure multi-party computation, homomorphic encryption Ethical data collection, annotation, and labeling practices, Adversarial threats to AI: data poisoning, model inversion attacks, membership inference attacks, adversarial examples, Defenses: adversarial training, input validation, model robustness evaluation, Tools: TensorFlow Privacy, PySyft, OpenDP, Anonymization libraries

Unit-IV Transparency, Explainability, and Trustworthy AI 08 Hrs.

The transparency imperative: black-box vs. interpretable vs. explainable models, Post-hoc explainability techniques: Attention visualization, Counterfactual explanations, Intrinsically interpretable models: decision trees, rule-based systems, linear models, Explainability for Large Language Models (LLMs): chain-of-thought reasoning, saliency maps, probing, Model Cards and Datasheets for Datasets: documenting AI systems for transparency, Building user trust through interface design, explanation presentation, and appropriate AI communication

Unit-V AI Governance, Policy, and Regulation 08 Hrs.

Global AI governance landscape: EU AI Act (risk-based classification: unacceptable, high-risk, limited-risk, minimal-risk), US AI Executive Order and NIST AI Risk Management Framework, China's AI governance regulations, India's National AI Strategy, Risk management in AI: risk identification, mitigation, and monitoring, , AI auditing and certification processes, Red-teaming and adversarial testing for AI systems, Corporate AI ethics boards, governance structures, and Chief AI Ethics Officers, Standards: IEEE standards for ethically aligned design, AI procurement and vendor assessment guidelines.

Unit-VI Responsible AI in Practice and Future Directions 05 Hrs.

End-to-end responsible AI development lifecycle: design, data, model, deployment, monitoring, Responsible AI in critical sectors: healthcare , finance, criminal justice (recidivism prediction), education, Generative AI ethics: deepfakes, synthetic media, copyright and intellectual property, non-consensual imagery, misinformation, Agentic AI ethics: autonomous decision-making, corrigibility, value alignment, AI moral agency, AI safety research: alignment problem, reward hacking, instrumental convergence, existential risk,, Future trends: AI rights and personhood, emotional AI ethics, open-source vs. proprietary AI ethics .

Text Books:

1. Virginia Dignum, "Responsible Artificial Intelligence: How to Develop and Use AI in a Responsible Way", Springer, 2019.
2. Mark Coeckelbergh, "AI Ethics", MIT Press, 2020.
3. Michael Kearns & Aaron Roth, "The Ethical Algorithm: The Science of Socially Aware Algorithm Design", Oxford University Press, 2019.

Reference Books:

1. Cathy O'Neil, "Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy", Crown Publishers, 2016.
2. Stuart Russell, "Human Compatible: Artificial Intelligence and the Problem of Control", Viking, 2019.

NPTEL Course:

1. Ethics in Engineering Practice https://onlinecourses.nptel.ac.in/noc22_hs22/preview
2. Responsible AI: Principles and Practice https://onlinecourses.nptel.ac.in/noc24_cs105/preview
3. Introduction to Machine Learning https://onlinecourses.nptel.ac.in/noc23_cs86/preview
4. Responsible & Safe AI Systems https://onlinecourses.nptel.ac.in/noc24_cs132/preview

Coursera Courses:

1. Responsible and Ethical AI
   https://www.coursera.org/learn/responsible-and-ethical-ai
2. Responsible Generative AI
   https://www.coursera.org/specializations/responsible generative-ai
3. Data Privacy, Ethics, and Responsible AI Specialization
   https://www.coursera.org/specializations/data-privacy-ethics-and-responsible-ai
4. Strategic AI Governance Specialization
   https://www.coursera.org/specializations/strategic ai-governance

Program: Artificial Intelligence and Machine Learning	Final Year B. Tech	Semester: VIII
Social Network Analysis (RCP23ACPE812)		

Pre-requisite: Probability and Statistics, Machine Learning

Course Objective(s):

1. Develop foundational knowledge of massive networks, including their structure, properties, and real-world applications.
2. Enhance analytical and problem-solving skills to address computational, algorithmic, and modeling challenges associated with large-scale networks.
3. Foster a research-oriented perspective by enabling students to analyze network structure, dynamics, and emerging trends in network science.

Course Outcomes: On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Analyse social networks using visualization techniques and structural measures.	L4	Analyze
CO2	Illustrate network growth patterns and ranking methodologies in complex networks.	L3	Apply
CO3	Examine methods for detecting communities, predicting links, and modelling information flow.	L3	Apply
CO4	Apply anomaly detection and representation learning approaches for network analysis.	L3	Apply

Social Network Analysis (RCP23ACPE812)
Course Contents

Unit-I Society & Network: 08 Hrs.

Introduction, Use of social networks, defining a network, types of network (link centric, node and link centric, local view, temporal view, generalization, real-world network), levels of social network analysis, graph visualization tools. Network Measures: Network basics, node centrality, assortativity, transitivity and reciprocity, similarity, degeneracy. Network Growth Models: Overview of real-world networks and their properties, brief introduction to Erdős Rényi Random Network Model, WattsStrogatz Model, and Preferential Attachment Model with their key characteristics and limitations.

Unit-II Link Analysis: 07 Hrs.

Application of link analysis, Signed networks: Balance Theory of Undirected Signed Networks, Status Theory of Signed Networks, Triad Balance vs Status, Strong and Weak Ties: Strength of a Tie, Triadic Closure, Dunbar Number, Local Bridges and Importance of Weak Ties, PageRank, DivRank, SimRank, PathSim.

Unit-III Community Detection: 07 Hrs.

Application of community detection, types of communities, community detection methods, Disjoint Community Detection: Node-centric community detection, modularity and community detection, Overlapping Community Detection: Clique Dynamics, Local Community Detection. Link Prediction: Applications of link prediction, Evaluating Link Prediction methods

Unit-IV Cascade Behaviours & Network Effects: 06 Hrs.

Preliminaries and Important Terminologies, Cascade Models, Probabilistic Cascades, Epidemic Models, Independent Cascade Models, Cascade Prediction.

Unit-V Anomaly Detection in Networks: 06 Hrs.

Outliers verses network based anomalies. Anomaly in Static Networks: Plain and attributed networks, relational learning, Anomaly in Dynamic Networks: Preliminaries, feature and decomposition-based approaches, Challenges in anomaly detection.

Unit-VI Graphical Representation Learning: 08 Hrs.

Intuition behind representation learning, representation learning methods. Graph Convolutional Network (GCN) and its variations and applications in social network analysis. Dynamic Graph Convolutional Networks (DGCN) & Continuous-Time Dynamic Graph Neural Networks (CTDGNN): Advanced models for analyzing evolving social networks

Text Books:

1. Tanmoy Chakraborty, "Social Network Analysis", 1st Edition, Wiley, 2021.
2. Stephen P Borgatti, Martin G. Everett, Jeffrey C. Johnson, "Analyzing Social Networks", Sage Publications Ltd, 2nd Edition, 2018.

Reference Books:

1. Xiaoming Fu, Jar-Der Luo, Margarete Boos, "Social Network Analysis Interdisciplinary Approaches and Case Studies", 1st Edition, CRC Press, 2020.
2. Dr. Krishna Raj P.M., Mr. Ankith Mohan, Dr. Srinivasa K.G, "Practical Social Network Analysis with Python (Computer Communications and Networks)", 1st Edition, Springer, 2019.
3. John Scott, "Social Network Analysis", 4th Edition, SAGE Publications Ltd, 2017.
4. Song Yang, Franziska Barbara Keller, Lu Zheng, "Social Network Analysis: Methods and Examples", 1st Edition, SAGE Publications, 2016.

Web Links:

1. A course on Social Network Analysis: https://onlinecourses.nptel.ac.in/noc22_cs117/preview

Program: Artificial Intelligence and Machine Learning	Final Year B. Tech	Semester: VIII
Computational Neuroscience(RCP23ACPE813)		

Pre-requisite: Artificial Intelligence, Machine Learning, Statistics and Programming Skills.

Course Objective:

This course aims to provide students with a strong foundation in the field of Cognitive Neuroscience, a field that studies the intricate links between the mind, the brain, and behaviour. Students will learn methods to replicate human behaviour of how to sense and perceive the world, act in it, learn and think about it, and remember it.

Course Outcomes: On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Explain the computational neural structure	L2	Understand
CO2	Illustrate coding and decoding models	L3	Apply
CO3	Describe neural circuit and network models	L2	Undertand
CO4	Apply information theory concepts on Brain mapping	L3	Apply

Computational Neuroscience(RCP23ACPE813)
Course Contents

Unit-I Introduction: 06 Hrs.

Descriptive model, Mechanistic model and Interpretive model, Properties of Neurons, recording neuronal responses, Spike trains and firing rates: Measuring Firing Rates, Tuning curves; Stimulus: The spike Triggered Average, White noise Stimuli, Multiple Spike Triggered Averages and Spike Triggered correlations, Spike-Train Statistics – Homogenous and Inhomogeneous Poisson Process, Auto correction Function, The Poisson Spike Generator, The Neural Code .

Unit-II Neural Encoding: 08 Hrs.

Introduction to retina, LGN, V1, area 17, Techniques of neural data collection, Reverse-Correlation Methods: Simple Cells, Spatial Receptive Fields, Temporal Receptive Fields, Response of a simple cell to counterphase grating, Space-time Receptive Fields; Linear Filtering, Non-linear input-output function, Basic encoding model, Impact of PCA on encoding model, Non-linear representation with Gaussian, Binomial and Poisson representation, The generalized linear model.

Unit-III Neural Decoding: 08 Hrs.

Encoding decoding, Discrimination: ROC curves, The likelihood ratio test; Population Decoding: optimal decoding method, Fisher Information; Spike-Train Decoding.

Unit-IV Information Theory: 06 Hrs.

Entropy and Mutual Information, Information and entropy maximization: for single Neuron, populations of neurons; Utilization in Retinal Ganglion cell Receptive Fields- Application, Entropy and information for spike trains

Unit-V Model Neurons (Neuroelectronic): 08 Hrs.

Significance of Neuroelectronic in neuroscience, Neuronal Biophysics- Membrane potentials, Single compartment models, Integrated and fire models, Voltage dependent conductance, The Hodgkin- Huxley Model, Channel Simulation, Synaptic Transmission Models, Synaptic Inputs to Integrate-and-Fire Models

Unit-VI Network Models: 06 Hrs.

Introduction - Importance of connectivity and dynamics, Firing-Rate Models - Dynamics of average firing rates, Feedforward - Neural mapping, Recurrent Networks: Linear and Nonlinear Recurrent Networks, Stability and oscillatory dynamics.

Text Books:

1. Jose Luis Bermudez, “Cognitive Science: An Introduction to the Science of the Mind”, Cambridge University Press, New York, 2nd Edition, 2014.
2. Jay Friedenberg, Gordon Silverman and Michael J. Spivey, “Cognitive Science: An Introduction to the Study of Mind”, SAGE Publication, 4th Edition, 2021.

Reference Books:

1. Michael Gazzaniga, Richard B Ivry, George R Mangun, "Cognitive Neuroscience the Biology of the Mind," W. W. Norton & Company Publication, 5th Edition, 2019.
2. Daniel Kolak, William Hirstein, Peter Mandik, Jonathan Waskan," Cognitive Science: An Introduction to Mind and Brain, Taylor and Francis, 1st Edition, 2006.

Web Links:

1. https://nptel.ac.in/courses/102105100

Program: Artificial Intelligence and Machine Learning	Final Year B.Tech	Semester: VIII
Reinforcement Learning NPTEL		

Prerequisite: Basic knowledge of Machine Learning.

Course Objective:

1. To introduce fundamental concepts of Reinforcement Learning and decision-making under uncertainty.
2. To develop an understanding of multi-armed bandit problems and exploration–exploitation trade-offs.
3. To analyze Markov Decision Processes and their solution methods.
4. To apply dynamic programming, temporal difference learning, and function approximation techniques.
5. To explore advanced RL methods such as deep reinforcement learning and hierarchical RL.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Define and explain the fundamental concepts of Reinforcement Learning, including multi-armed bandits and exploration–exploitation trade-offs.	L2	Understand
CO2	Apply bandit algorithms such as UCB, PAC, median elimination, and policy gradient methods to solve decision-making problems.	L3	Apply
CO3	Explain and analyze Markov Decision Processes and Bellman optimality principles for policy evaluation and improvement.	L4	Analyze
CO4	Apply and analyze dynamic programming and temporal difference (TD) learning methods for solving reinforcement learning problems.	L4	Analyze
CO5	Analyze advanced reinforcement learning techniques such as function approximation, least squares methods, Deep Q-Networks (DQN), and hierarchical RL.	L4	Analyze

Reinforcement Learning NPTEL
NPTEL Course Contents

Week 1

Introduction

Week 2

Bandit algorithms – UCB, PAC.

Week 3

Bandit algorithms –Median Elimination, Policy Gradient.

Week 4

Full RL MDPs.

Week 5

Bellman Optimality.

Week 6

Dynamic Programming TD Methods.

Week 7

Eligibility Traces.

Week 8

Function Approximation.

Week 09

Least Squares Methods.

Week 10

Fitted Q, DQN & Policy Gradient for Full RL.

Week 11

Hierarchical RL.

Week 12

POMDPs.

Text Books:

1. Richard S. Sutton, Andrew G. Barto, "Reinforcement Learning: An Introduction", 2nd Edition, MIT Press, 2018.

2. Csaba Szepesvári, “Algorithms for Reinforcement Learning”, Morgan & Claypool Publishers, 2010 (updated reprint editions available).
3. Marco Wiering, Martijn van Otterlo, “Reinforcement Learning: State-of-the-Art”, Springer, 2012.
4. Dimitri P. Bertsekas, “Reinforcement Learning and Optimal Control”, Athena Scientific, 2019.
5. Shangtong Zhang, Richard S. Sutton, “Reinforcement Learning: An Introduction (Draft/Updated Version with Python Examples)”, MIT Press (latest online edition), 2023.

Reference Books:

1. Rafael Ris-Ala, “Fundamentals of Reinforcement Learning”, Springer, 2023.
2. Yves Hilpisch, “Reinforcement Learning for Finance”, O’Reilly Media, 2024.
3. Stefano V. Albrecht, Filippos Christianos, Lukas Schäfer, “Multi-Agent Reinforcement Learning: Foundations and Modern Approaches”, MIT Press, 2023.
4. Stuart Russell, Peter Norvig, “Artificial Intelligence: A Modern Approach”, 4th Edition, Pearson, 2020.
5. Richard S. Sutton, Andrew G. Barto, “Reinforcement Learning: An Introduction”, 2nd Edition, MIT Press, 2018.

Weblinks:

1. Massachusetts Institute of Technology, “Introduction to Reinforcement Learning (OpenCourseWare)”, Available: https://ocw.mit.edu
2. Stanford University, “CS234: Reinforcement Learning Course Materials”, Available: https://cs234.stanford.edu
3. DeepMind, “Reinforcement Learning Resources and Publications”, Available: https://deepmind.com
4. OpenAI, “Spinning Up in Deep Reinforcement Learning”, Available: https://spinningup.openai.com
5. Google, “Machine Learning Crash Course – Reinforcement Learning Section”, Available: https://developers.googl learning

Program: Artificial Intelligence and Machine Learning	Final Year B.Tech.	Semester: VIII
Internship (OJT) cum Project (RCP23IPELX10)		

Prerequisites:

1. Fundamental knowledge of engineering concepts and programming
2. Basic understanding of professional ethics and communication skills
3. Exposure to laboratory courses and mini-projects
4. Teamwork and problem-solving skills

Course Objective(s):

1. To provide practical exposure to industrial and professional environments.
2. To bridge the gap between academic learning and industry practices.
3. To develop technical, communication, teamwork, and managerial skills.
4. To enable application of engineering knowledge for solving real-world problems.
5. To familiarize students with modern tools, technologies, and professional ethics.
6. To prepare students for industry-oriented careers through project implementation and professional experience.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Apply engineering knowledge and technical skills in industrial environments.	L3	Apply
CO2	Analyze and solve practical engineering problems using appropriate tools and techniques.	L4	Analyze
CO3	Demonstrate professional ethics, teamwork, communication, and organizational skills.	L3	Apply
CO4	Utilize modern engineering tools and technologies for assigned tasks and projects.	L3	Apply
CO5	Prepare technical reports, presentations, and project documentation effectively.	L6	Create
CO6	Adapt to professional work culture and demonstrate readiness for professional careers.	L3	Apply

Internship (OJT) cum Project (RCP23IPELX10) Course Contents

Overview of the OJT Process

The On-Job Training (OJT) program begins with an introduction to workplace ethics, safety practices, organizational culture, and professional conduct to prepare students for industrial environments. Students are then exposed to industrial processes, workflow practices, tools, and modern technologies relevant to their domain of study.

During the technical training phase, students work on assigned industrial tasks and projects under the guidance of faculty mentors and industry supervisors. The program emphasizes the application of engineering concepts, teamwork, communication skills, and problem-solving abilities in real-world professional settings.

The later stages of the OJT focus on project implementation, report writing, technical documentation, and presentation preparation. Students are required to maintain logbooks and progress records throughout the training period. At the end of the semester, students present their project work through demonstrations and viva-voce examinations, followed by comprehensive evaluation and feedback.

Internship (OJT) Schedule, Duration and Credits

The Internship / On-Job Training (OJT) cum Project is an integral part of the Final Year B.Tech. program and carries a total of **18 academic credits** toward completion of the degree requirements. Each credit corresponds to **40 hours** of work, resulting in approximately **550–600 hours** of industrial training and project work over one semester.

The full-time OJT program is conducted during the designated semester as per the academic schedule. The duration of the OJT is one complete semester in the final year. Faculty mentors are assigned for mentoring, monitoring, and evaluating students throughout the OJT period.

Approximately 50% of the students undergo OJT during Semester VII while the remaining students continue academic activities in the institute. In Semester VIII, the arrangement is interchanged to ensure equal academic and industrial exposure for all students.

To avoid academic scheduling conflicts and ensure fair evaluation, oral, practical, and End Semester Examinations for both Semester VII and Semester VIII will be conducted at the end of Semester VIII. Students are issued a combined marksheet covering both semesters.

Types of External OJT Opportunities

Sr. No.	Type of OJT	Examples / Description
1	Industry OJT	Industrial internships with or without stipend.
2	Government / PSU OJT	BARC, SAMEER, Railways, ISRO, etc.
3	Research OJT	IITs, NITs, IISc, IIMs, and other research institutes.
4	Institute-Based OJT	OJT at institutes approved by RCPIT and departments.
5	Other Approved OJT	Any approved industrial/research work relevant to the domain.

OJT / Internship Sources

To facilitate OJT and internship opportunities, AICTE has signed Memorandums of Understanding (MoUs) with various industries, government organizations, and training institutions. These collaborations provide students with industrial exposure, skill development opportunities, research internships, and professional training through multiple recognized platforms and organizations.

Students may also approach organizations such as the Board of Apprenticeship Training (BOAT) and Board of Practical Training (BOPT) for additional training opportunities.

Major OJT / Internship Sources

Sr. No.	Organization / Platform	Nature of Opportunity
1	Internshala	Internship and industry training opportunities
2	NETiit (Taiwan)	International internship opportunities
3	HireMee	Skill-based internships and employability support
4	IGNCA	Research and cultural project opportunities
5	CCEI, Republic of Korea	International innovation and creative economy internships
6	IIWM, Bangalore	Waste management and sustainability projects
7	Engineering Council of India (ECI)	Engineering and professional development activities
8	Fourth Ambit	Industry training and technical internships
9	LinkedIn	Professional networking and internship opportunities
10	Telecom Sector Skill Council (TSSC)	Telecom and communication technology training
11	SCHOLARSMERIT	Internship and skill enhancement programs
12	Studenting Era	Student internship and academic support activities
13	MSME	Industry exposure and entrepreneurship opportunities
14	BOAT	Apprenticeship and industrial training programs
15	BOPT	Practical and apprenticeship-based training opportunities

Evaluation Metrics

Sr. No.	Evaluation Component	Marks
1	Internal Review 1	100
2	Final Internal Review	100
3	End Semester Evaluation (OJT Viva / Presentation)	200
Total		**400**

Evaluation Parameters

The student shall be evaluated based on the following parameters:

1. Understanding of assigned work.
2. Progress and task completion.
3. Technical skill development.
4. Learning ability and initiative.
5. Professional behaviour and discipline.
6. Communication and presentation skills.
7. Problem solving and contribution.
8. Quality of work and innovation.
9. Logbook maintenance and report documentation.
10. Application of engineering knowledge.

Necessary Documents

Students are required to submit and maintain the following documents during the OJT period:

1. No Objection Certificate (NOC)
2. Undertaking for opting OJT
3. OJT Joining Form
4. Parent/Guardian Undertaking Form
5. Contact Details and OJT Objectives Form
6. Student Logbook / Daily Activity Record
7. Internal Review Evaluation Sheets
8. External Supervisor Evaluation Form
9. Internal Supervisor Feedback Form
10. Student Feedback Form
11. SDG Mapping Form
12. Final OJT Report and Presentation
13. OJT Completion Certificate

Scheme of Examination

Component	Marks
Continuous Internal Assessment	200
End Semester OJT Evaluation (Report and Presentation)	200
Total	**400**

Credits

- Total Credits: 18
- 1 Credit = 40 Hours of Work
- Minimum Duration: 550–600 Hours of OJT and Project Work over one semester.

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Program: Artificial Intelligence and Machine Learning	Final Year B. Tech	Semester: VIII
AI in Web3 (RCP23ACSC801)		

Pre-requisite: Basic Programming (Python/JavaScript), Fundamentals of AI, Data Structures and Algorithms, Computer Networks, Basic Cryptography.

Course Objectives:

1. Understand the fundamentals of Blockchain, Web3, and Artificial Intelligence.
2. Explore decentralized applications (DApps) and smart contract development.
3. Apply Generative AI to blockchain-based applications and decentralized ecosystems.
4. Develop AI-enabled Web3 solutions using blockchain platforms and decentralized technologies.
5. Understand security, privacy, ethical, and governance aspects of AI-powered Web3 systems.

Course Outcomes: On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Explain the concepts of Blockchain, Web3, and decentralized applications.	L2	Understand
CO2	Design and analyze blockchain-based decentralized applications using smart contracts.	L6	Create
CO3	Apply Generative AI techniques for blockchain development and intelligent decentralized services.	L3	Apply
CO4	Evaluate AI-enabled blockchain solutions considering scalability, privacy, and security.	L5	Evaluate
CO5	Demonstrate responsible and ethical implementation of AI in decentralized Web3 ecosystems.	L3	Apply

AI in Web3 (RCP23ACSC801)
Course Contents

Unit-I Introduction to Blockchain, Web3 and AI: 05 Hrs.

Evolution of Web1/Web2/Web3, blockchain fundamentals, DLT, consensus, smart contracts, decentralization, AI in Web3.

Unit-II Decentralized Applications: 05 Hrs.

DApp architecture, Ethereum, wallets, tokens, Solidity, IPFS, Web3 frameworks, deployment and applications.

Unit-III Generative AI and Blockchain: 05 Hrs.

LLMs, AI-assisted smart contracts, blockchain analytics, DeFi, DAOs, NFTs, prompt engineering.

Unit-IV Responsible AI in Web3: 05 Hrs.

Smart contract security, AI risks, privacy, explainability, governance, ethics, regulations, capstone.

Online Course:

1. Decentralized Applications (Dapps):
   https://www.coursera.org/learn/decentralized-apps-onblockchain
2. Introduction to Blockchain Technologies:
   https://www.coursera.org/learn/introductionblockchain- technologies
3. Generative AI and Blockchain:
   https://www.coursera.org/learn/generative-ai-and-blockchain

Useful Courses:

1. Blockchain Platforms –
   https://www.coursera.org/learn/blockchain-platforms
2. Blockchains, Tokens, and The Decentralized Future –
   https://www.coursera.org/learn/blockchains-tokens-decentralized-future